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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

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TITLE OF THE INVENTION (500 characters max)

TOPICAL DELIVERY OF PHTHALOCYANINES

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Respectfully submitted,

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Docket Number CWRU-P60-048

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TOPICAL DELIVERY OF PHTHALOCYANINES

Field of Invention

The present invention is directed to topical pharmaceutical compositions comprising a series of novel phthalocyanines suitable for use as photosensitizers for photodynamic therapy. More particularly, the present invention is directed to a series of new aluminum (Al) and silicon (Si) phthalocyanines having substituted amine or quaternary ammonium axial ligands, and the use of these new phthalocyanine compositions for the therapeutic treatment of cancer. In addition, the present invention is directed to the methods of synthesizing these new compositions.

Background of the Invention

Photodynamic therapy, hereinafter also referred to as "PDT", is a relatively new process for treating cancer wherein visible light is used to activate a substance, such as a dye or drug, which then attacks, through one or more photochemical reactions, the tumor tissue thereby producing a cell killing, or cytotoxic, effect. It has been discovered that when certain non-toxic photodynamic sensitizers, such as hematoporphyrin derivative ("HpD" or "Photofrin® I"), which is extracted from serum and/or components thereof, are applied to the human or animal body, they are selectively retained by the cancerous tissue while being eliminated by the healthy tissue. As a result, after the administration of a photodynamic substance and the waiting of a certain period of time depending upon the type of photosensitizer utilized (i.e., two to three days after HpD treatment), substantially higher levels of the photosensitizer are retained in the cancerous tissue.

The tumor or cancerous tissue containing the photosensitizer can then be exposed to therapeutic light of an appropriate wavelength and at a specific intensity for activation. The light can be directly applied through the skin to the cancerous area from a conventional light source (e.g., laser, sun lamp, white light sources with appropriate filters, etc.), or in cases where the cancerous tissue is located deeper within the body, through surgical or non-surgical entry such as by the use of fiber optic illumination systems, including flexible fiber optic catheters, endoscopic devices, etc. The light energy

and the photosensitizer cause a photochemical reaction which kills the cell in which the photosensitizer resides.

As a result, by topically applying a photosensitizer to the animal or human body, waiting for a sufficient period of time for the photosensitizer to permeate throughout the body while dissipating from normal tissue more rapidly than from cancer tissue, and exposing the cancerous region during the sensitive period to suitable light of sufficient intensity, the preferential destruction of the cancerous tissue will occur.

The mechanisms by which the photosensitizers produce their killing effect on the host cells upon illumination by an appropriate light source are not precisely defined and are the subject of continuing research. However, it is thought that there are at least two general mechanisms by which the photosensitizers are chemically altered upon illumination. The first general reaction mechanism involves energy transfer from the excited photosensitizer to oxygen present in the cancerous tissue. The excited photosensitizer transfers its additional energy to the oxygen, producing singlet molecular oxygen (SMO or $^1O_2$) which consequentially alters essential cell components.

More particularly, in the first general reaction mechanism, it is thought that the light energy causes the photosensitizer to become excited from the ground state, S_0, to the first excited singlet state, S_1. The photosensitizer's excited singlet state, S_1, is then transformed by intramolecular coupling to the lowest lying triplet state T_1. Through a direct intermolecular process discussed more particularly by John G. Parker of The John Hopkins University, Baltimore, Md., in U.S. Pat. Nos. 4,576,173; 4,592,361; and 4,827,938, the photosensitizer transfers this energy to oxygen molecules present in the tissue and raises them from the ground triplet to the first excited electronic singlet state $^1O_2$. The singlet molecular oxygen, $^1O_2$, destroys or alters vital cellular components such as the cell membrane, etc., ultimately inducing necrosis and destroying the cancerous tissue.

The process by which biological damage occurs as a result of the optical excitation of a photosensitizer in the presence of oxygen is generally referred to as "photodynamic action". A more detailed discussion concerning the use of photodynamic action in the treatment of cancer is discussed by Thomas J. Dougherty, William R. Potter,

and Kenneth R. Weishaupt of Health Research, Inc., Buffalo, N.Y., in a series of patents, i.e. U.S. Pat. Nos. 4,649,151; 4,866,168; 4,889,129; and 4,932,934, concerning improved hematoporphyrin and porphyrin derivatives including dihematoporphyrin ether (DHE), the purified form of HpD, and methods utilizing same, for photodynamic therapy.

The second general mechanism thought to be involved in the killing effect produced by certain photosensitizers involves the production of free radicals. The reactions of these radicals with organic molecules and/or with oxygen results in the biochemical destruction of the diseased tissue.

Although the exact effective mechanisms of the photochemical reactions which produce death of the cancer cells is not clearly understood and varies depending upon the type of photosensitizer utilized, what is clear is that photodynamic therapy is effective for the preferential destruction of cancerous tissue. Furthermore, photodynamic therapy has several attractive features over conventional methods for treating cancer such as chemotherapy, radiation, surgical procedures, etc., in that the photosensitizers utilized are generally non-toxic, concentrate or remain preferentially in cancer cells, can be utilized with other modes of treatment since PDT does not interfere with other chemicals or processes, etc.

As a result, photodynamic therapy is now used experimentally for the treatment of malignant diseases in humans and animals. For example, photodynamic therapy has been used successfully for the treatment of a broad range of cancers including metastatic breast tumors, endometrial carcinomas, bladder tumors, malignant melanoma, Kaposi's sarcoma, basal cell carcinoma, chondrosarcoma, squamous cell carcinoma, prostate carcinoma, laryngeal papillomas, mycosis fungoides, superficial cancer of the tracheobronchial tree, cutaneous/mucosal papilloma, gastric cancer, enteric cancer, etc.

The drug in current clinical use is "Photofrin® II" a purified version of hematoporphyrin derivative (HpD, or "Photofrin® I"). HpD and Photofrin® II are complex mixtures of substances and have been the subject of numerous investigations to identify their active compounds. In addition, other porphyrins and porphyrin-like compounds such as chlorins (see U.S. Pat. Nos. 4,656,186; 4,693,885; and 4,861,876) and enlarged porphyrins, naphthalocyanines, phthalocyanines, platyrins, porphycenes

(see U.S. Pat. Nos. 4,649,151 and 4,913,907), purpurins, texaphyrins, and verdins have been investigated as photosensitizers. Numerous other substances, such as "merocyanine 540", xanthenes (Rhodamine 123 6 G&B) cationic cyanic dyes, chalcogenapyryllium dyes, phenothiazinium derivatives, tetracycline, berbine sulphate, acridine orange, and fluorescein have also been used as photosensitizers, however, the porphyrin derivatives are generally preferred because they absorb in the long wave length region (red region) of the visible spectrum.

The specific reactions used by many of the above substances to produce the killing effect in cancer cells on exposure to excitatory light are in most instances not known or well understood. As mentioned above, research continues in this area in order to more fully understand the cytotoxic effects produced by the various photosensitizers.

Notwithstanding the above, although many of the above identified substances have demonstrated enhanced effects in photodynamic therapy, these substances also produce various side effects which limit their use for photodynamic therapy. The most predominant side effect exhibited by many of the currently utilized substances is the development of uncontrolled photosensitivity reactions in patients after the systemic administration of the photosensitizer and the exposure of the patient to normal sunlight. In this regard, on exposure to the sun, the photodynamic therapy patients can develop generalized skin photosensitization. As a result, the patient after receiving systemic injections of a photosensitizing substance is required to avoid bright light, especially sunlight for periods of about four to eight weeks.

Furthermore, since many of the above photosensitizers bind to other non-cancerous cells, some healthy cell destruction can also occur. Similarly, although many of the photosensitizers are soluble in water, large dosages are required for cellular uptake and/or treatment. Thus, use of many of the above indicated photosensitizers is normally limited to patients with severe cancerous tumors and continuing research is being conducted in order to produce photosensitizing substances, and/or methods of administering such substances, that avoid these side reactions as well as produce enhanced photosensitizing effects.

Considerable attention has recently been directed to a group of compounds having the phthalocyanine ring system. These compounds, called phthalocyanines, hereinafter also abbreviated as "Pc", are a group of photoactive dyes that are somewhat structurally similar (i.e. have nitrogen containing ring structure) to the porphyrin family. Phthalocyanines are azaporphyrins consisting of four benzoindole nuclei connected by nitrogen bridges in a 16-membered ring of alternating carbon and nitrogen atoms around a central metal atom (i.e. $C_{32}H_{16}N_8M$) which form stable chelates with metal cations. In these compounds, the ring center is occupied by a metal ion (such as a diamagnetic or a paramagnetic ion) that may, depending on the ion, carry one or two simple ligands. In addition, the ring periphery may be either unsubstituted or substituted.

Since E. Ben-Hur and I. Rosenthal disclosed the potential use of phthalocyanines as photosensitizers in 1985 (E. Ben-Hur and I. Rosenthal, The phthalocyanines: A new class of mammalian cell photosensitizers with a potential for cancer phototherapy, *Int. J. Radiat. Biol.* 47, 145-147, 1985), a great deal of research has followed producing a number of phthalocyanines for photodynamic therapy. Although prior studies with phthalocyanines have been generally disappointing, primarily because of the poor solubility characteristics of the basic ring, some of these compounds have attractive characteristics.

For example, unlike some of the porphyrin compounds, phthalocyanines strongly absorb clinically useful red light with absorption peaks falling between about 600 and 810 nm (Abernathy, Chad D., Anderson, Robert E., Kooistra, Kimberly L., and Laws, Edward R., Activity of Phthalocyanine Photosensitizers against Human Glioblastoma in Vitro, *Neurosurgery*, Vol. 21, No. 4, pp. 468-473, 1987). Although porphyrins absorb light poorly in this wavelength region, as a result of the increased transparency of biological tissues at longer wavelengths, red light is normally used for photodynamic therapy. Thus, the greater absorption of red light by the phthalocyanines over porphyrins indicates deeper potential penetration with the phthalocyanines in photodynamic treatment processes.

Furthermore, it has been found that the addition of certain metal cations (i.e. diamagnetic metal cations such as aluminum) to the phthalocyanine ring will, in some

instances, create a fairly stable chelate with enhanced photosensitizing tumoricidal activity. While the mechanisms for producing the photoreactions are not clear (i.e. it is not known whether singlet oxygen or hydroxyl radicals, etc. are produced), the choice of the metal cation is apparently critical in that certain metals (i.e., paramagnetic metals) may actually inhibit the phototoxic properties of the resulting compound. Abernathy, et al., pp. 470-471.

In addition, the phthalocyanines offer many benefits over the porphyrin components as photosensitizers in that the phthalocyanines are relatively easy to synthesize, purify, and characterize in contrast to the porphyrins, which are often difficult to prepare. Similarly, the metal phthalocyanines are exceptionally stable compounds in comparison to the porphyrin or porphyrin-like compounds. As a result, certain metallic phthalocyanines, such as aluminum phthalocyanine tetrasulfonate (AlPcS) and chloroaluminum phthalocyanine (AlPcCl), offer a number of advantages over porphyrins as therapeutic agents for photodynamic therapy.

However, notwithstanding some of the benefits indicated above, only a few of the many possible types of ring-substituted phthalocyanines belonging to this group have been examined. By far the most attention has been given to sulfonated phthalocyanines and to phthalocyanines with peripheral substituents carrying hydroxy, alkoxy, and amino substituents. Very little attention has been given to phthalocyanines with complex metal ligands.

The limited variety of phthalocyanines which have been tested vary greatly in their photosensitizing activity. Metal-free phthalocyanines show poor photodynamic activity (Abernathy, C. D., R. E. Anderson, K. L. Kooistra, & E. R. Laws, Jr., "Activity of Phthalocyanine Photosensitizers Against Human Glioblastoma in vitro", Neurosurgery 21, pp 468-473, 1987; Chan, W. S., J. F. Marshall, G. Y. F. Lam, & I. R. Hart, "Tissue Uptake, Distribution, and Potency of the Photoactivatable Dye Chloroaluminum Sulfonated Phthalocyanine in Mice Bearing Transplantable Tumors", *Cancer Res.*) 48, pp 3040-3044, 1988, Sonoda, M., C. M. Krishna, & P. Riesz, "The Role of Singlet Oxygen in the Photohemolysis of Red Blood Cells Sensitized by Phthalocyanine Sulfonates", Photochem Photobiol. 46, pp. 625-632, 1987) as do phthalocyanines containing

paramagnetic metals. In contrast, those containing diamagnetic metals, such as Al, Sn, and Zn, are active as a result of the long half-life of the triplet state (Chan, W. S., J. F. Marshall, G. Y. F. Lam, & I. R. Hart, "Tissue Uptake, Distribution, and Potency of the Photoactivatable Dye Chloroaluminum Sulfonated Phthalocyanine in Mice Bearing Transplantable Tumors", *Cancer Res.* 48, pp. 3040-3044, 1988; Sonoda, M., C. M. Krishna, & P. Riesz, "The Role of Singlet Oxygen in the Photohemolysis of Red Blood Cells Sensitized by Phthalocyanine Sulfonates", *Photochem. Photobiol.* 46, pp. 625-632, 1987). While in general there appears to be an increase in photosensitizing ability with lipophilicity (Berg, K., J. C. Bommer, & J. Moan, "Evaluation of Sulfonated Aluminum Phthalocyanines for use in Photochemotherapy. Cellular Uptake Studies", *Cancer Letters* 44 pp. 7-15, 1989) some highly lipophilic derivatives, such as a tetraneopentoxy derivative, are poor photosensitizers (Rosenthal, I., E. Ben-Hur, S. Greenberg, A. Concepcion-Lam, D. M. Drew, & C. C. Leznoff, "The Effect of Substituents on Phthalocyanine Phototoxicity", *Photochem. Photobiol.* 46, pp. 959-963, 1987).

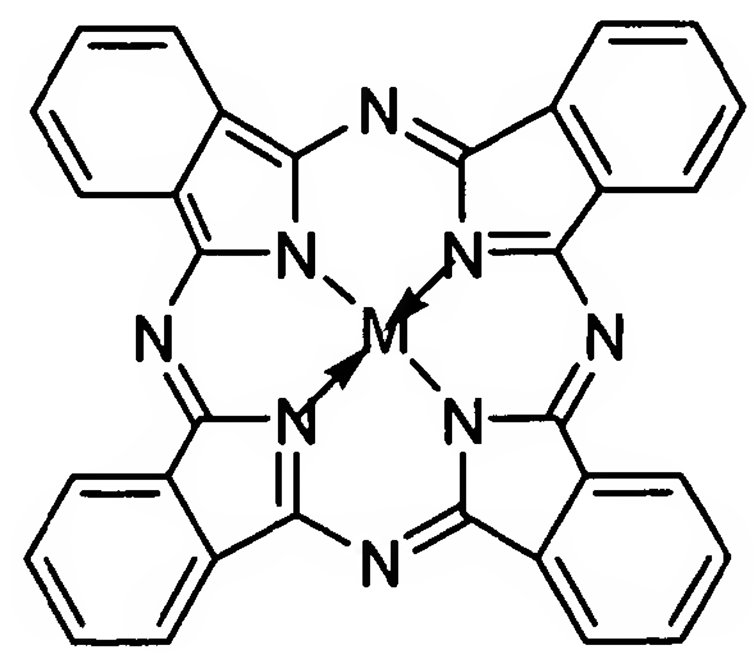
There is a need for a convenient form of a photosensitizer that can be administered locally. Local administration of a photosensitizer would provide an opportunity to reduce unwanted side-effects that are currently associated with systemically administered photosensitizers.

Summary of the Invention

With the results of this preliminary work in mind, a series of compositions comprising new aluminum and silicon phthalocyanines having relatively simple ligands carrying NR_2 or NR_3 + functions were prepared and studied. Topical administration of compositions for photodynamic therapy offers the advantage of limiting therapy only to sites of involvement and prevents unwanted adverse effects especially the prolonged generalized skin photosensitivity such as that encountered in Photofrin® PDT.

In one aspect, the present invention is directed to topical pharmaceutical compositions comprising a phthalocyanine compound, with modifying moieties linked to the central metal, which is either aluminum (Al), germanium (Ge), gallium (Ga), tin (Sn), or silicon (Si). Specifically, the present invention relates to a series of aluminum, germanium, gallium, tin or silicon phthalocyanines having an axial group, or groups,

carrying, or terminating in, an amine or quaternary ammonium function. The compounds useful in the invention can be generally characterized by the following Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein M is $(G)_a\,Y[(OSi(CH_3)_2\,(CH_2)_bN_c(R')_d\,(R'')_e)_f\,X_g]_p$

Y is selected from Si, Al, Ga, Ge, or Sn;

R' is selected from H, C, CH_2, CH_3, C_2H_5, C_4H_9, C_4H_8NH, C_4H_8N, $C_4H_8NCH_3$, C_4H_8S, C_4H_8O, C_4H_8Se, CH_2CH_3, $(CH_2)_3(CH_3)_2$, $OC(O)CH_3$, OC(O), $(CH_3)_2(CH_2)_{11}$, CS, CO, CSe, OH, $C_4H_8N(CH_2)_3CH_3$, $(CH_2)_2N(CH_3)_2$, $C(O)C_{27}H_{30}N_2O$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

R'' is selected from H, SO_2CH_3, $(CH_2)_2N(CH_3)_2$, $(CH_2)_{11}CH_3$, $C(S)NHC_6H_{11}O_5$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

G is selected from OH, CH_3, and $(CH_3)_3C(CH_3)_2$;

X is selected from I, F, Cl, or Br;

a is 0 or 1;

b is an integer from 2 to 12;

c is 0 or 1;

d is an integer from 0 to 3;

e is an integer from 0 to 2;

f is 1 or 2;

g is 0 or 1;

n is an integer from 1 to 12;

o is an integer from 1 to 11; and

p is 1 or 2.

In an additional aspect, the present invention relates to methods of administering phthalocyanines. The phthalocyanines disclosed herein exhibit enhanced characteristics which make them well suited for topical application in photodynamic therapy when utilized alone or in combination with a pharmaceutical carrier.

In a further aspect, the present invention is directed to various methods for destroying cancer tissue comprising topically administering to the cancer tissue or surrounding tissue an effective amount of a phthalocyanine composition having an axial group, or groups, carrying, or terminating in an amine or quaternary ammonium function, and applying light of suitable wavelength and intensity to activate the composition thereby exerting a cell killing, or cytotoxic, effect on the cancer tissue.

Brief Description of the Drawings

The following is a brief description of the drawings which are presented for the purpose of illustrating the invention and not for the purpose of limiting them.

FIG. 1 is a graph illustrating the photodynamic efficacy of the various compositions of the present invention in comparison to AlPcCl. The phthalocyanine composition compounds of the present invention were tested for their photodynamic efficiency against Chinese hamster fibroblast V79 cells by colony formation. Monolayer cultures were treated with the indicated phthalocyanine composition for 18 hours, irradiated with various fluences of red light, and immediately trypsinized and replated at appropriate aliquots in triplicate. Colonies of at least 50 cells were counted after 7-10 days. The plating efficiency of the untreated cells was approximately 90%.

FIG. 2 is a graph demonstrating the percent survival of the compositions of the present invention in comparison to ALPcCl in relation to intracellular phthalocyanine (nmole/10^7 cells) and light fluence (kJ/m^2). In this regard, in FIG. 2 the data of FIG. 1 were replotted as a function of the product of the amount of cell-associated phthalocyanine and the light fluence.

FIG. 3 is a graph which compares the percent survival of L5178Y strain R cells receiving photodynamic therapy and treated with: PcIV, represented by the open circles;

PcXII, represented by the solid circles; PcX, represented by the open squares; and PcXVIII, represented by the solid squares, at varying doses of light.

FIG. 4 shows the tumor volume response of chemically-induced benign skin papillomas in SENCAR mice, to photodynamic therapy with PcIV.

FIG. 5 is a graph which compares the relative cellular uptake of PcIV, PcIV hydrochloride, and PcIV pyruvate into human breast cancer MCF-7c3 cells *in vitro*.

FIG. 6a is a confocal fluorescence image of PcIV in vertical cross section of human skin.

FIG. 6b is a confocal fluorescence image of PcIV in *en face* horizontal optical section of human skin.

FIG. 6c is a confocal fluorescence image of a negative control of skin only plus exposure to vehicle.

FIG. 7a shows a confocal fluorescence image of a confocal fluorescence image of a negative control of a keratome biopsy exposed to PcIV for 1 hour.

FIG. 7b shows a confocal fluorescence image of a keratome biopsy exposed to PcIV for 2 hours.

FIG. 7c shows a confocal fluorescence image of a keratome biopsy exposed to PcIV for 4 hours.

FIG. 7d shows a confocal fluorescence image of a cross-section of a keratome biopsy exposed to PcIV for 4 hours.

FIG. 8a shows a confocal fluorescence image of a keratome biopsy exposed to PcIV.

FIG. 8b shows a confocal fluorescence image of a keratome biopsy exposed to PcIV-pyruvate.

FIG. 8c shows a confocal fluorescence image of a keratome biopsy exposed to PcIV-HCl.

FIG. 8d shows a confocal fluorescence image of a cross section of a keratome biopsy exposed to PcIV.

FIG. 8e shows a confocal fluorescence image of a cross section of a keratome biopsy exposed to PcIV-pyruvate.

FIG. 8f shows a confocal fluorescence image of a cross section of a keratome biopsy exposed to PcIV-HCl.

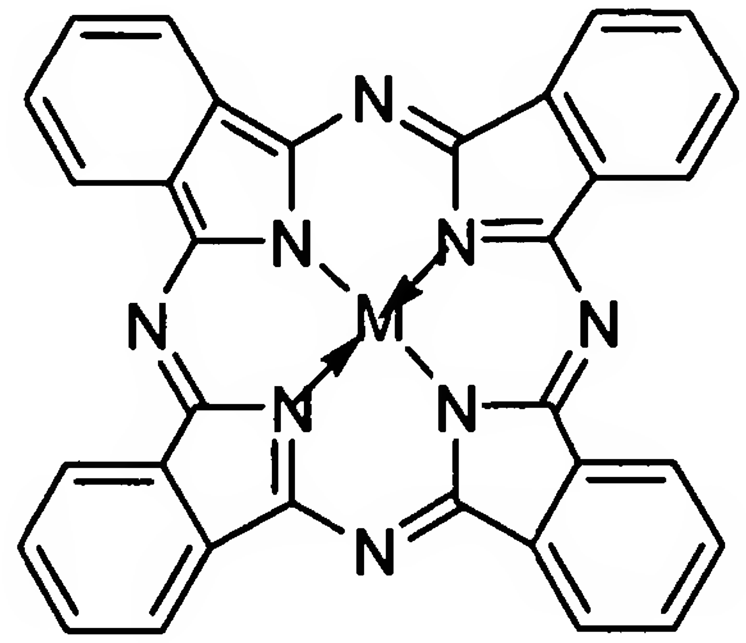
Detailed Description of the Invention

The present invention relates to methods of preparing topical phthalocyanine compositions (or compounds) suitable for use as photosensitizers for use in photodynamic therapy. Specifically, the invention relates to a series of new Al or Ga and/or Si, Ge, or Sn phthalocyanines having substituted amine or quaternary ammonium axial ligands attached to the central metal, and the use of these phthalocyanine compositions for the treatment of cancer through photosensitization.

Although research has recently been directed to the use of various phthalocyanines for photodynamic therapy, this activity has been principally directed to phthalocyanines with peripheral substituents, and little, if any, attention has been given to phthalocyanines with complex metal ligands. In the compositions of the present invention, axial ligands carrying or, terminating in an amine function or a quaternary ammonium function are attached to the central metal. As a result, it is believed that these more complex axial ligands give the new phthalocyanine compositions the potential to bind to the various species that assist in transporting the composition to and from their targets, as well as enhance the potential for the phthalocyanines to bind to their specific target cells.

Some of the phthalocyanines having substituted amine or quaternary ammonium axial ligands attached to either aluminum or silicon as the central metal are much more effective in producing photodynamic activity when compared with chloroaluminum phthalocyanine (AlPcCl). The enhanced cytotoxic effects produced are due to the increased cellular uptake of the compositions and/or the increased loss of clonogenicity as a function both of the concentration of the phthalocyanine and the red light fluence.

The phthalocyanine compositions can be generally characterized by the following formula (I) or a pharmaceutically acceptable salt thereof:



(I)

wherein M is $(G)_a Y[(OSi(CH_3)_2 (CH_2)_b N_c(R')_d (R'')_e)_f X_g]_p$

Y is selected from Si, Al, Ga, Ge, or Sn;

R' is selected from H, C, CH_2, CH_3, C_2H_5, C_4H_9, C_4H_8NH, C_4H_8N, $C_4H_8NCH_3$, C_4H_8S, C_4H_8O, C_4H_8Se, CH_2CH_3, $(CH_2)_3(CH_3)_2$, $OC(O)CH_3$, OC(O), $(CH_3)_2(CH_2)_{11}$, CS, CO, CSe, OH, $C_4H_8N(CH_2)_3CH_3$, $(CH_2)_2N(CH_3)_2$, $C(O)C_{27}H_{30}N_2O$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

R" is selected from H, SO_2CH_3, $(CH_2)_2N(CH_3)_2$, $(CH_2)_{11}CH_3$, $C(S)NHC_6H_{11}O_5$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

G is selected from OH, CH_3, and $(CH_3)_3C(CH_3)_2$;

X is selected from I, F, Cl, or Br;

a is 0 or 1;

b is an integer from 2 to 12;

c is 0 or 1;

d is an integer from 0 to 3;

e is an integer from 0 to 2;

f is 1 or 2;

g is 0 or 1;

n is an integer from 1 to 12;

o is an integer from 1 to 11; and

p is 1 or 2.

In certain embodiments M is represented by $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_3^+I^-$; $CH_3SiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_3^+I^-$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_3^+I^-]_2$; $Si[OSi(CH_3)_2(CH_2)_4NH_2]_2$; $Si[OSi(CH_3)_2(CH_2)_4NHSO_2CH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_4NHCSNHC_6H_{11}O_5]_2$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3OCOCH_3$; $Si[OSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3]_2 2I^-$; $(CH_3)_3C(CH_3)_2SiOSiOSi(CH_3)_2(CH_2)_4NCOC_{27}H_{30}N_2O$; $HOSiOSi(CH_3)_2(CH_2)_3OH$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8O$; $AlOSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3I^-$; $HOSiOSi(CH_3)_2(CH_2)_8N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8O]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8S$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2)_3(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3NCS$; $HOSiOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$; or $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NH]_2$.

In preferred embodiments, M is represented by $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8O$; $HOSiOSi(CH_3)_2(CH_2)_8N(CH_3)_2$ or a pharmaceutically acceptable salt thereof. In the most preferred embodiment, M is represented by $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ or a pharmaceutically acceptable salt thereof.

Pharmaceutically acceptable salt refers to the relatively non-toxic, inorganic and organic acid addition salts of the inhibitor(s). These salts can be prepared in situ during the final isolation and purification of the inhibitor(s), or by separately reacting a purified inhibitor(s) in its free base form with a suitable organic or inorganic acid, and isolating the salt thus formed. Representative salts include the hydrobromide, hydrochloride, sulfate, bisulfate, phosphate, nitrate, acetate, pyruvate, valerate, oleate, palmitate, stearate, laurate, benzoate, lactate, phosphate, tosylate, citrate, maleate, fumarate, succinate, tartrate, naphthylate, mesylate, glucoheptonate, lactobionate, and laurylsulphonate salts, and the like. (See, for example, Berge et al. (1977) "Pharmaceutical Salts", *J. Pharm. Sci.* 66:1-19). Preferred pharmaceutically acceptable

salts are the hydrochloric and pyruvate salts. The most preferred pharmaceutically acceptable salt is the pyruvate.

Topical or transdermal administration of phthalocyanine(s) or a pharmaceutically acceptable salt thereof may be accomplished using, powders, sprays, ointments, pastes, creams, lotions, gels, solutions, or patches. The active component may be mixed under sterile conditions with a pharmaceutically acceptable carrier, and with any preservatives, buffers, or propellants which may be required. The ointments, pastes, creams, and gels may contain excipients in addition to phthalocyanine(s).

Powders and sprays can contain, in addition to a phthalocyanine, excipients such as lactose, talc, silicic acid, aluminum hydroxide, calcium silicates, and polyamide powder, or mixtures of these substances. Sprays can additionally contain customary propellants, such as chlorofluorohydrocarbons and volatile unsubstituted hydrocarbons, such as butane and propane.

The phthalocyanine can be alternatively administered by aerosol. This is accomplished by preparing an aqueous aerosol, liposomal preparation, or solid particles containing the compound. A nonaqueous (e.g., fluorocarbon propellant) suspension could be used. Sonic nebulizers are preferred because they minimize exposing the agent to shear, which can result in degradation of the compound.

Ordinarily, an aqueous aerosol is made by formulating an aqueous solution or suspension of the agent together with conventional pharmaceutically acceptable carriers and stabilizers. The carriers and stabilizers vary with the requirements of the particular compound, but typically include nonionic surfactants (Tweens, Pluronics, or polyethylene glycol), innocuous proteins like serum albumin, sorbitan esters, oleic acid, lecithin, amino acids such as glycine, buffers, salts, sugars, or sugar alcohols. Aerosols generally are prepared from isotonic solutions.

Transdermal patches have the added advantage of providing controlled delivery of a phthalocyanine to the body. Such dosage forms can be made by dissolving or dispersing the agent in the proper medium. Absorption enhancers can also be used to increase the flux of the inhibitor(s) across the skin. The rate of such flux can be

controlled by either providing a rate controlling membrane or dispersing the peptidomimetic in a polymer matrix or gel.

"Pharmaceutically acceptable carrier" as used herein means a pharmaceutically acceptable material, composition or vehicle, such as a liquid or solid filler, diluent, excipient, solvent or encapsulating material, involved in carrying or transporting the subject chemical from one organ or portion of the body, to another organ or portion of the body. Each carrier must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not injurious to the patient. Some examples of materials which can serve as pharmaceutically acceptable carriers include: (1) sugars, such as lactose, glucose, and sucrose; (2) starches, such as corn starch and potato starch; (3) cellulose, and its derivatives, such as sodium carboxymethyl cellulose, ethyl cellulose, and cellulose acetate; (4) powdered tragacanth; (5) malt; (6) gelatin; (7) talc; (8) excipients, such as cocoa butter and suppository waxes; (9) oils, such as peanut oil, cottonseed oil, safflower oil, sesame oil, olive oil, corn oil, and soybean oil; (10) glycols, such as propylene glycol; (11) polyols, such as glycerin, sorbitol, mannitol, and polyethylene glycol; (12) esters, such as ethyl oleate and ethyl laurate; (13) agar; (14) buffering agents, such as magnesium hydroxide and aluminum hydroxide; (15) alginic acid; (16) pyrogen-free water; (17) isotonic saline; (18) Ringer's solution; (19) ethyl alcohol; (20) phosphate buffer solutions; and (21) other non-toxic compatible substances employed in pharmaceutical formulations.

The specific process utilized to synthesize the aluminum and silicon phthalocyanine compounds of the present invention, and the enhanced results produced through the use of these new compounds for photodynamic therapy, are more particularly described below in the following examples.

Examples

Synthesis of Phthalocyanines

$CH_3OSi(CH_3)_2(CH_2)_3N(CH_3)_2$ --Under argon gas a solution of CH_3MgCl in tetrahydrofuran (3.0M, 45 mL) was added dropwise to a cool (ice bath) solution of $(CH_3O)_3Si(CH_2)_3N(CH_3)_2$ (11 mL) in tetrahydrofuran (100 mL), and the resulting suspension was stirred for 2 hours while being kept cool (at about 5 ^{o}C). Methanol (20

mL) then was added to the suspension and the resulting mixture was filtered. The solid was washed with ether (50 mL) and the washings and filtrate were combined and concentrated on a rotary evaporator (45 °C). The concentrate was fractionally distilled under vacuum (45 torr) and a selected fraction (86 - 88 ° C) was retained (5.0 g, 55%): NMR ($CDCl_3$) δ 3.42 (s, 3 H), 2.24 (m, 2 H), 2.20 (s, 3 H), 1.49 (m, 2 H), 0.57 (m, 2 H), 0.10 (s, 3 H). The compound is a colorless liquid.

$AlPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$--Compound I. A mixture of $CH_3OSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (203 mg) produced above and a suspension of AlPcOH xH_2O (56 mg) and 2-ethylpyridine (15 mL) that had been dried by distillation (3 mL of distillate) was refluxed for 45 minutes and filtered. The filtrate was evaporated to dryness on a rotary evaporator (about.40 °C.) and the solid was dissolved CH_2Cl_2 (2 mL). Hexanes (3 mL) were added to the solution and the resulting suspension was filtered. The solid was washed (benzene and hexanes), vacuum dried (65 °C.), and weighed (63 mg, 98% assuming $AlPcOH3H_2O$); NMR (C_5D_5N, 70 °C) δ .65 (m, 1,4-PcH), 8.28 (m, 2,3-PcH), 1.63 (s, 3 H), 0.99 (m, 2 H), -0.50 (m, 2 H), -1.80 (m, 2 H), -2.33 (s, 3 H).

The compound is blue and is soluble in CH_2Cl_2 and toluene.

$AlPcOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$ --Compound II. A mixture of $AlPcOSi(CH_3)_2$ $(CH_2)_3N(CH_3)_2$ (30 mg), benzene (10 mL), and CH_3I (15 μL) was refluxed for 1.5 hours, cooled, and filtered. The solid was vacuum dried (60 °C) and weighed (31 mg, 86%): NMR (C_5D_5N, 70 °C.) δ 9.75 (m, 1,4-PcH), 8.34 (m, 2,3-PcH), 2.90 (s, 3 H), 2.02 (m, 2 H), -0.53 (m, 2 H), -1.87 (m, 2 H), -2.40 (s, 3 H).

The compound is a blue solid and is soluble in CH_2Cl_2 and CH_3OH but is insoluble in toluene and H_2O.

$CH_3SiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$--Compound III. Procedures in this synthesis that were carried out under low light conditions (room lights off, shades drawn) are identified by the symbol 1. A mixture of $CH_3OSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (224 mg) and a suspension of $CH_3SiPcOH$ (117 mg) and pyridine (25 mL) that had been dried by distillation (1) was slowly distilled (1) for 3 h (10 mL of distillate) and then filtered (1, no solid). The filtrate was evaporated to dryness on a rotary evaporator (1, 75 °C.), and the solid was dissolved in CH_2Cl_2 (1, 2 mL). Hexanes (30 mL) were added to the solution (1)

and the resulting suspension was filtered (1). The solid was washed (hexanes), vacuum dried (65 °C), and weighed (11 mg, 76%): mp >260 °C; NMR ($CDCl_3$) δ 9.63 (m, 1,4-PcH), 8.33 (m, 2,3-PcH), 1.74 (s, 3 H), 1.01 (m, 2 H, -1.18 (m, 2 H), -2.25 (m, 2 H), -2.96 (s, 6 H), -6.35 (s, 3 H).

The compound is dark green and is soluble in CH_2Cl_2 and toluene. Solutions of it are rapidly photolyzed by white light.

$HOSiPcOSi(CH_3)_2(CH_2)_3N(_3)_2$ --Compound I. A mixture of $CH_3SiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (35 mg), $N(C_2H_5)_3$ saturated with H_2O (0.2 mL), and toluene (70 mL) was irradiated with an incandescent light (300 W in 35 mm slide projector) for 15 minutes. The resulting suspension was concentrated on a rotary evaporator (~45° C.) and the concentrate (~5 mL) was diluted with hexanes (1 mL). The suspension formed was filtered and the solid was washed (hexanes), vacuum dried (65 C), and weighed (33 mg, 96%): mp>260° C.; NMR (dimethylformamide-d_7, 70 °C) δ 9.68 (m, 1,4-PcH), 8.47 (m, 2,3-PcH), 1.52 (s, 3 H), 0.74 (m, 2 H), -1.11 (m, 2 H), -2.27 (m,2 H), -2.89 (s, 3 H). MS-HRFAB exact mass m/z calculated for $C_{39}H_{35}N_9O_2Si_2$M+7.17.2452. Found 717.2422.

The compound is blue and is soluble in CH_2Cl_2 and toluene.

$HOSiPcOSi(CH_3)_2(CH_2)_3\ N(CH_3)_3{}^+I^-$ --Compound V. A mixture of $HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (24 mg), CH_3I (25 μL), and benzene (10 mL) was refluxed for 1.5 hours, cooled, and filtered. The solid was washed (benzene), vacuum dried (65° C.), and weighed (23 mg, 81%): NMR (dimethylformamide-d_7, 70° C.) δ9.66 (m, 1,4-PcH), 8.45 (m, 2,3-PcH), 2.87 (s, NCH_3), 2.06 (m, γ-CH_2), -0.97 (m, β-CH_2), -2.25 (m, α-CH_2), -2.83 (s, $SiCH_3$). MS-HRFAB exact mass m/z calculated for $C_{40}H_{38}N_9O_2Si_2$ $(M\text{-}I)^+$ 732.2687. Found 732.2668.

The compound is blue. It is soluble in CH_2Cl_2 and CH_3OH but is insoluble in toluene and H_2O.

$Sipc[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$. A mixture of $CH_3OSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (239 mg) and a suspension of $SiPc(OH)_2$ (232 mg) and 2-ethylpyridine (30 mL) that had been dried by distillation (~2 mL of distillate) was slowly distilled for 2 hours (~5 mL of

distillate). The resulting solution was filtered, the filtrate was evaporated to dryness on a rotary evaporator (~60° C.), and the solid was dissolved in CH_2Cl_2 (3.5 mL). The CH_2Cl_2 solution was diluted with hexanes (~40 mL), the suspension formed was filtered, and the solid was washed (hexanes), air dried, and weighed (263 mg, 76%); NMR ($CDCl_3$), δ 9.63 (m, 1,4-PcH), 8.34 (m, 2,3-PcH), 1.65 (s, NCH_3), 0.90 (m, γ-CH_2), -1.10 (m, β-CH_2), -2.26 (m, α-CH_2), -2.87 (s, $SiCH_3$).

The compound is blue and is soluble in CH_2Cl_2 and toluene.

$SiPc[OSi(CH_3)_2(CH_2)_3N(CH_3)_3)^+I^-]_2$ --Compound VI. A mixture of $SiPc[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$ produced above (30 mg), CH_3I (36 .μ.L) and benzene (5 mL) was refluxed for 1.5 hours, cooled, and filtered. The solid was washed (benzene, hexanes), vacuum dried (60° C.), and weighed (32 mg, 79%): NMR (CD_3OD) δ 9.63 (m, 1,4-PcH), 8.41 (m, 2,3-PcH), 1.65 (s, NCH_3), 0.90 (m, γ-CH_2), -1.10 (m, β-CH_2), -2.21 (m, α-CH_2), -2.90 (s, $SiCH_3$).

The compound is blue and is soluble in CH_2Cl_2 and CH_3OH but is insoluble in toluene. It disperses in H_2O but doses not dissolve in it.

Additional Phthalocyanine Compounds

$SiPc[OSi(CH_3)_2(CH_2)_4NH_2]_2$ Compound VII

A mixture of $CH_3OSi(CH_3)_2(CH_2)_4NH_2$ (100 μL, 0.53 mmol), $SiPC(OH)_2$ (65 mg, 0.11 mmol) and pyridine (15 ml) was distilled for 30 minutes (~5 ml distillate) and filtered. The filtrate was evaporated to dryness with a rotary evaporator (~70° C.). The solid was dissolved in ethanol (4 ml), precipitated from the solution with water (3 ml), recovered by filtration, washed (ethanol-water solution, 2:1), vacuum dried (~60° C.) and weighed (81 mg, 0.097 mmol, 88%): UV-Vis (toluene) λ_{max} 669 nm; NMR ($CDCl_3$) δ 9.67 (m, 1,4-PcH), 8.36 (m, 2,3-PcH), 1.71 (t, δ-CH_2), 0.10 (m, γ-CH_2), -1.33 (m, β-CH_2), -2.20 (m, α-CH_2), -2.87 (s, $SiCH_3$). MS-HRFAB exact mass, m/z: calculated for $C_{44}H_{48}N_{10}O_2Si_3$ $(M)^+$, 832.3270; found, 832.3261, 832.3274. The compound is blue and is soluble in CH_2Cl_2, dimethylformamide, pyridine and ethanol.

$HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$ Compound X

To prepare $CH_3OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$, a solution of $CH_3OSi(CH_3)_2(CH_2)_3Cl$ (5.06 g, 30 mmol), $CH_3CH_2NH(CH_2)_2N(CH_3)_2$ (5.0 mL, 61 mmol) and CH_3OH (5.0 ml) was refluxed for 6 hours and then distilled under gradually reduced pressure (20 torr final). The remainder was diluted with ether (20 ml) and filtered. The solid was washed (ether) and the washings and the filtrate were combined and concentrated with a rotary evaporator (~25° C.). The concentrate was fractionally distilled under vacuum (7 mtorr) and a selected fraction (30°-35° C.) was retained (432 mg, 1.8 mmol, 6%): NMR ($CDCl_3$) δ 3.40 (s, CH_3O), 2.53 (m, NCH_2CH_3 and $CH_2CH_2NCH_3$), 2.37 (m, γ-CH_2 and $CH_2CH_2NCH_3$), 2.21 (s, NCH_3), 1.46 (m, β-CH_2), 0.97 (t, NCH_2CH_3), 0.52 (m, α-CH_2), 0.07 (s, $SiCH_3$). The compound is a colorless oil.

All steps but the finally drying step of this procedure were carried out under low-intensity illumination. To prepare $CH_3SiPcOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$, a mixture of the $CH_3OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$ (432 mg, 1.8 mmol) and a suspension of $CH_3SiPcOH$ (291 mg, 0.51 mmol) and pyridine (120 ml) that had been dried by distillation (~23 ml of distillate) was slowly distilled for 3 hours (~5 ml of distillate) and then filtered. The filtrate was evaporated to dryness with a rotary evaporator (~80° C.). The solid was dissolved in CH_2Cl_2 (1 ml), precipitated from the solution with hexanes (20 ml), recovered by filtration, washed (CH_3OH and hexanes), vacuum dried (~90° C.) and weighed (306 mg, 0.39 mmol, 76%): NMR (CD_2Cl_2) δ 6 9.68 (m, 1,4-Pc H), 8.40 (m, 2,3-Pc H), 2.01 (s, NCH_3), 1.85 (s, NCH_2CH_2N), 1.83 (q, NCH_2CH_3), 0.98 (m, γ-CH_2), 0.61 (t, NCH_2CH_3), -1.18 (m, β-CH_2), -2.39 (m, α-CH_2), -2.94 (s, $Si(CH_3)_2$), -6.33 (s, $SiPcCH_3$). The compound is green and is soluble in CH_2Cl_2 and toluene. Solutions of it are rapidly photolyzed by white light.

To prepare $HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$, a mixture of the $CH_3SiPcOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$ (300 mg, 0.38 mmol), toluene (600 ml) and $(C_2H_5)_3N$ saturated with H_2O (2.2 ml) was irradiated with incandescent light (300 W projector lamp) for 40 minutes, and then concentrated on a rotary evaporator (~70° C.). The concentrate (~5 ml) was diluted with hexanes (2.5 ml) and filtered. The solid was washed (toluene), dissolved in CH_2Cl_2 (2 ml), precipitated from the solution with hexanes (20 ml), recovered by filtration, was washed (hexanes), vacuum dried (~90° C.), and weighed (136 mg, 0.17 mmol, 45%): UV-vis (toluene) λ_{max} 670 nm; NMR (CD_2Cl_2,

7.6 mM) δ 9.28 (m, 1,4-Pc H), 8.30 (m, 2,3-Pc H), 1.93 (s, NCH_3), 1.77 (s, NCH_2CH_2N), 1.71 (q, NCH_2CH_3), 0.85 (m, γ-CH_2), 0.49 (t, NCH_2CH_3), -1.24 (m, β-CH_2), -2.43 (m, α-CH_2), -3.02 (s, $SiCH_3$). Anal. calculated for $C_{43}H_{44}N_{10}O_2Si_2$: C,65.45; H,5.62; N,17.75. Found: C,65.18; H,5.51; N,17.74. The compound is blue. It is soluble in toluene, CH_2Cl_2, dimethylformamide and ethanol.

$SiPc[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$ Compound XII

A mixture of $CH_3OSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (201 mg, 1.1 mmol) and a suspension of $SiPc(OH)_2$ (232 mg, 0.40 mmol) and 2-ethylpyridine (30 ml) that had been dried by distillation (~1 ml of distillate) was slowly distilled for 1.5 hours (~11 ml of distillate). The resulting solution was filtered, and the filtrate was evaporated to dryness with a rotary evaporator (~40° C.). The solid formed was extracted (CH_2Cl_2 -hexanes solution, 1:4, 15 ml), recovered from the extract by rotary evaporation (~40° C.), dissolved in CH_2Cl_2 (1.5 ml), precipitated from the solution with hexanes (18 ml), recovered by filtration, washed (hexanes), vacuum dried (~70° C.) and weighed (110 mg, 0.13 mmol, 33%): UV-vis (toluene) λ_{max} 669 nm; NMR ($CDCl_3$) .δ 9.61 (m, 1,4-Pc H), 8.31 (m, 2,3-Pc H), 1.55 (s, NCH_3), 0.80 (m, γ-CH_2), -1.14 (m, β-CH_2), -2.29 (m, α-CH_2), -2.89 (s, $SiCH_3$). MS-HRFAB exact mass, m/z: calculated for $C_{46}H_{53}N_{10}O_2Si_3$ $(M+H)^+$, 861.3661; found, 861.3627, 861.3638. The compound is blue and is soluble in CH_2Cl_2, dimethylformamide and toluene.

$SiPc[OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2]_2$ Compound XVIII

A mixture of $CH_3OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$ (191 mg, 0.77 mmol) and a suspension of $SiPc(OH)_2$ (144 mg, 0.25 mmol) and pyridine (45 ml) that had been dried by distillation (~9 ml of distillate) was slowly distilled for 1 hours (~3 ml of distillate) and then filtered. The filtrate was evaporated to dryness with a rotary evaporator (~80° C.), and the solid was extracted (CH_2Cl_2, 10 ml), recovered from the extract by rotary evaporation (~40° C.), washed twice (ethanol-water solution, 1:4), vacuum dried (~90° C.) and weighed (123 mg, 0.12 mmol, 48%): UV-vis (toluene) λ_{max} 668 nm; NMR ($CDCl_3$) δ 9.64 (m, 1,4-Pc H), 8.33 (m, 2,3-Pc H), 2.03 (s, NCH_3), 1.91 (s, NCH_2CH_2N), 1.84 (q,NCH_2CH_3), 1.04 (m, γ-CH_2), 0.64 (t, NCH_2CH_3), -1.14 (m, γ-CH_2), -2.39 (m, α-CH_2), -2.89 (s, $SiCH_3$). MS-HRFAB exact mass, m/z: calculated for

$C_{54}H_{70}N_{12}O_2Si_3$ $(M+H)^+$, 1003.5131; found, 1003.5085, 1003.5100. The compound is blue and is soluble in CH_2Cl_2, dimethylformamide and toluene.

$HOSiPcOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$ Compound XXVIII

To prepare $CH_3OSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$, a mixture of $CH_3OSi(CH_3)_2(CH_2)_3Cl$ (3.05 g, 18 mmol), $NH[(CH_2)_3N(CH_3)_2]_2$ (8.0 mL, 36 mmol), K_2CO_3 (0.488 g, 3.5 mmol) and CH_3OH (1.0 ml) was heated in oil bath (~110° C.) for 48 hours and filtered. The filtrate was fractionally distilled under vacuum (5 mtorr) and a selected fraction (99°-102° C.), was retained (543 mg): NMR ($CDCl_3$) δ 3.40 (s, CH_3O), 2.33 (m, $CH_2CH_2CH_2NCH_3$), 2.19 (s, NCH_3), 1.61 (quintet, $CH_2CH_2CH_2NCH_3$), 1.43 (m, β-CH_2), 0.55 (m, α-CH_2), 0.07 (s, $SiCH_3$). The product is a yellow oil.

All steps but the finally drying step of this procedure were carried out under low-intensity illumination. To prepare $CH_3SiPcOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$, a mixture of the crude $CH_3OSi(CH_3)_2(CH_2)_3N](CH_2)_3N(CH_3)_2]_2$ (322 mg) and a suspension of $CH_3SiPcOH$ (302 mg, 0.53 mmol) and pyridine (170 ml) that had been dried by distillation (~23 ml of distillate) was slowly distilled for 3 hours (~20 ml of distillate) and then filtered. The filtrate was evaporated to dryness on a rotary evaporator (~80° C.). The solid was washed (ethanol-water solution, 1:2) and chromatographed (Al_2O_3V, 3.5x15 cm^3, ethyl acetate-CH_3OH solution, 9:1) and the resulting solid was vacuum dried (~60° C.) and weighed (194 mg, 0.23 mmol, 43%): NMR ($CDCl_3$) .δ9.60 (m, 1,4-Pc H), 8.29 (m, 2,3-Pc H), 2.08 (s, NCH_3), 1.96 (t, $CH_2CH_2CH_2NCH_3$), 1.73 (t, $CH_2CH_2CH_2NCH_3$), 1.11 (quintet, $CH_2CH_2CH_2NCH_3$), 0.96 (m, γ-CH_2), -1.18 (m, β-CH_2), -2.46 (m, α-CH_2), -2.98 (s, $Si(CH_3)_2$), -6.39 (s, $SiPcCH_3$). The compound is green and is soluble in CH_2Cl_2 and toluene. Solutions of it are rapidly photolyzed by white light.

(Pc 27). A mixture of $CH_3SiPcOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$ (180 mg, 0.21 mmol), toluene (360 ml), $(C_2H_5)_3N$ (18 ml) and H_2O (1.5 ml) was irradiated with incandescent light (300 W projector lamp) for 25 minutes and then evaporated to dryness with a rotary evaporator (~35° C.). The solid was chromatographed (Al_2O_3, 3x14 cm^3, ethyl acetate-CH_3OH solution, 9: 1) and the resulting solid was dissolved in CH_2Cl_2 (2 mL), precipitated from the solution with pentane (12 mL), recovered by filtration, washed (CH_2Cl_2 -pentane solution, 1:6; pentane), vacuum dried (~60° C.) and weighed

(74.3 mg, 0.086 mmol, 41%): UV-vis (dimethylformamide) λ_{max} 668 nm; NMR (CD_2Cl_2, 6.7 mM) δ 9.14 (m, 1,4-Pc H), 8.12 (m, 2,3-PcH), 1.84 (s, NCH_3), 1.71 (t, $NCH_2CH_2CH_2NCH_3$), 1.47 (t, $CH_2CH_2CH_2NCH_3$), 0.83 (quintet, $CH_2CH_2CH_2NCH_3$), 0.64 (m, γ-CH_2), -1.41 (m, β-CH_2), -2.61 (m, α-CH_2), -3.17 (s, $SiCH_3$). MS-HRFAB exact mass, m/z: calculated for $C_{47}H_{53}N_{11}O_2Si_2$ $(M+H)^+$, 860.4001; found, 860.4020, 860.4011. The compound is blue and is soluble in CH_2Cl_2, dimethylformamide and toluene.

$HOSiPcOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$ Compound XXVIII

To prepare $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$, a solution of $CH_3OSi(CH_3)_2(CH_2)_3Cl$ (3.09 g, 19 mmol), $HNC_4H_8N(CH_3)$ (4.0 mL, 36 mmol) and CH_3OH (1.0 mL) was heated in an oil bath (~110° C.) for 22 hours and allowed to stand for 8 h. The resultant was decanted and the upper layer was retained (2.40 g): NMR ($CDCl_3$) δ 3.40 (s, CH_3O), 2.45 (m, NCH_2CH_2N), 2.32 (m, γ-CH_2), 2.26 (s, NCH_3), 1.51 (m, β-CH_2), 0.55 (m, α-CH_2), 0.08 (s, $SiCH_3$). The product is a yellow oil.

All steps but the finally drying step of this procedure were carried out under low-intensity illumination. To prepare $CH_3SiPcOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$ A mixture of the crude $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$ (162 mg) and a suspension of $CH_3SiPcOH$ (201 mg, 0.35 mmol) and pyridine (90 ml) that had been dried by distillation (~9 ml of distillate) was slowly distilled for 3 hours (~10 ml of distillate) and then filtered. The filtrate was evaporated to dryness on a rotary evaporator (~80° C.). The solid was washed (ethanol-water solution, 1:4), vacuum dried (~60° C.) and weighed (252 mg, 0.33 mmol, 94%): NMR (7.3 mM, $CDCl_3$) .δ 9.61 (m, 1,4-Pc H), 8.31 (m, 2,3-PcH), 2.25 (s, NCH_3), 1.65 (m, NCH_2CH_2N), 0.90 (m, γ-CH_2), -1.25 (m, β-CH_2), -2.38 (m, α-CH_2), -2.98 (s, $Si(CH_3)_2$), -6.38 (s, $SiPcCH_3$). The compound is green and is soluble in CH_2Cl_2 and toluene. Solutions of it are rapidly photolyzed by white light.

A mixture of the $CH_3SiPcOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$ (200 mg, 0.26 mmol), toluene (400 ml), $(C_2H_5)_3N$ (4.0 mL) and H_2O (1.0 mL) was irradiated with incandescent light (300 W projector lamp) for 20 minutes, and then concentrated on a rotary evaporator (~70° C.). The concentrate (~5 mL) was diluted with hexanes (3.0 mL) and filtered. The solid was washed (toluene), dissolved in CH_2Cl_2 (6 mL), precipitated from

the solution with hexanes (12 mL), recovered by filtration, washed (hexanes), vacuum dried (~60° C.), and weighed (82.9 mg, 0.11 mmol, 42%): UV-vis (dimethylformamide) λ_{max} 668 nm; NMR ($CDCl_3$, 7.8 mM) .δ 9.15 (m, 1,4-PcH), 8.18 (m, 2,3-PcH), 2.16 (s, NCH_3), 1.61 (m, NCH_2CH_2N), 0.76 (m, γ-CH_2), -1.37 (m, β-CH_2), -2.49 (m, α-CH_2), -3.10 (s, $SiCH_3$). MS-HRFAB exact mass, m/z: calculated for $C_{42}H_{40}N_{10}O_2Si_2$ $(M+H)^+$, 773.2953; found, 773.2944, 773.2950. The compound is blue and is soluble in CH_2Cl_2, dimethylformamide and toluene.

The following compounds were made in a fashion similar to that used for the above compounds.

$SiPc[OSi(CH_3)_2(CH_2)_4NHSO_2CH_3]_2$ Compound VIII A solution of CH_3SO_2Cl, $SiPc[OSi(CH_3)_2(CH_2)_4NH_2]_2$, $(C_2H_5)_3N$ and CH_2Cl_2 was stirred, and the product was isolated, chromatographed and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{46}H_{52}N_{10}O_6S_2Si_2$ $(M)^+$, 988.2821; found, 988.2817, 988.2777.

$HOSiPCOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$ Compound IX A mixture of CH_3 $OSi(CH_3)_2$ $(CH_2)_4NH_2$, $CH_3SiPcOH$ and pyridine was partially distilled and the resulting $CH_3SiPcOSi(CH_3)_2(CH_2)_4NH_2$ was isolated and recrystallized. A solution of this compound, CH_3SO_2Cl, $(C_2H_5)_3N$ and CH_2Cl_2 was stirred and the $CH_3SiPcOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$ formed was isolated and chromatographed. Finally, a mixture of this intermediate, CH_2Cl_2, H_2O and $(C_2H_5)_3N$ was irradiated with light and the product was isolated, chromatographed and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{39}H_{35}N_9O_4SSi_2$ $(M)^+$, 781.2071; found, 781.2049, 781.2074.

$SiPc[OSi(CH_3)_2(CH_2)_4NHCSNHC_6H_{11}O_5]_2$ Compound XI A mixture of 2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl isothiocyanate, $SiPc[OSi(CH_3)_2(CH_2)_4NH_2]_2$ and benzene was refluxed and the resulting $SiPc[OSi(CH_3)_2(CH_2)_4NHCSNHC_{14}H_{19}O_9]_2$ was isolated. A solution of this compound and CH_3OH was treated with NH_3 gas and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{58}H_{70}N_{12}O_{12}S_2Si_3$ $(M)^+$, 1274.3986; found, 1274.3988, 1274.4024.

$HOSiPcOSi(CH_3)_2(CH_2)_3OCOCH_3$ Compound XIII A mixture of $ClSi(CH_3)_2(CH_2)_3OCOCH_3$, CH_3 SiPcOH and pyridine was refluxed, and the resulting

$CH_3SiPcOSi(CH_3)_2(CH_2)_3OCOCH_3$ was isolated. A solution of this compound and toluene was irradiated with light and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{39}H_{32}N_8O_4Si_2$ $(M)^+$, 732.2085; found, 732.2100, 732.2084

$SiPc[OSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3]_2\ 2I^-$ Compound XIV A solution of $CH_3(CH_2)_{11}I$, $SiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ and tetrahydrofuran was refluxed, and the product was isolated and recrystallized. Anal. calculated for $C_{70}H_{102}I_2N_{10}O_2Si_3$: C,57.84; H,7.07; I,17.46; N,9.64. Found: C,58.19; H,6.52; I,17.40; N,9.04, 9.63, 9.63.

$(CH_3)_3C(CH_3)_2SiOSiPcOSi(CH_3)_2(CH_2)_4NCOC_{27}H_{30}N_2O$ Compound XV A solution of $CH_3OSi(CH_3)_2(CH_2)_4NH_2$, $(CH_3)_3C(CH_3)_2SiOSiPcOH$ and pyridine was partially distilled and the resulting $(CH_3)_3C(CH_3)_2$ $SiOSiPcOSi(CH_3)_2(CH_2)_4NH_2$ was isolated A solution of this compound and CH_2Cl_2 was mixed with a mixture of rhodamine B base, $(COCl)_2$ and benzene which had been partially distilled, and the product was isolated and chromatographed: MS-HRFAB exact mass, m/z: calculated for $C_{72}H_{75}N_{11}O_4Si_3$ $(M)^+$, 1241.5311; found 1241.5295, 1241.5265.

$HOSiPCOSi(CH_3)_2(CH_2)_3OH$ Compound XVII A solution of $CH_3SiPcOSi(CH_3)_2(CH_2)_3OCOCH_3$, CH_3OH, K_2CO_3 and CH_2Cl_2 was stirred, the reaction product was worked up, and the resulting $CH_3SiPcOSi(CH_3)_2(CH_2)_3OH$ was isolated. A solution of this compound and toluene was irradiated with light and the product was isolated and chromatographed: MS-HRFAB exact mass, m/z: calculated for $C_{37}H_{30}N_8O_3$ Si_2 $(M)^+$, 690.1979; found, 690.1982, 690.1966.

$HOSiPcOSi(CH_3)_2(CH_2)_3NC_4H_8O$ Compound XIX A solution of $CH_3OSi(CH_3)_2(CH_2)_3Cl$, morpholine and CH_3OH was refluxed and the resulting $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8O$ was isolated and distilled. A suspension of this compound, $CH_3SiPcOH$ and pyridine was partially distilled, and the $CH_3SiPcOSi(CH_3)_2(CH_2)_3NC_4H_8O$ was isolated and recrystallized. Finally, a mixture of this intermediate, toluene, $(C_2H_5)_3N$ and H_2O was irradiated with light, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{41}H_{37}N_9O_3Si_2$ $(M+H)^+$, 760.2636; found, 760.2620, 760.2610.

$AlPcOSi(CH_3)_2(CH_2)_3N^+(CH_3)_2)(CH_2)_{11}CH_3I^-$ Compound XXI A mixture of $CH_3(CH_2)_{11}I$ and $AlPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ was warmed, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{51}H_{59}AlIN_9OSi$ $(M)^+$, 995.3472; found, 995.3444, 995.3428

$HOSiPcOSi(CH_3)_2(CH_2)_8N(CH_3)_2$ Compound XXII A solution of $CH_2{=}CH(CH_2)_6Br$, $(CH_3)_2NNH_2$ and ether was stirred, the reaction mixture was worked up with HCl, $NaNO_3$ and NaOH, and the resulting $CH_2{=}CH(CH_2)_6N(CH_3)_2$ was isolated and distilled. A solution of this compound, $(CH_3)_2SiHCl$, $CHCl_3$, $H_2PtCl_6.xH_2O$ and isopropanol was warmed and the $CH_3OSi(CH_3)_2(CH_2)_8N(CH_3)_2.HCl$ formed was isolated. Next, a suspension of this intermediate, $CH_3SiPcOH$ and pyridine was partially distilled, and the $CH_3SiPcOSi(CH_3)_2(CH_2)_8N(CH_3)_2$ obtained was isolated and recrystallized. Finally, a solution of this compound and CH_2Cl_2 was irradiated with light and the product was isolated, chromatographed, and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{44}H_{45}N_9O_2Si_2$ $(M+H)^+$, 778.3313; found, 788.3300, 788.3290.

$SiPC[OSi(CH_3)_2(CH_2)_3NC_4H_8O_2$ Compound XXIII A suspension of $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_1O$, $SiPc(OH)_2$ and pyridine was partially distilled, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{50}H_{56}N_{10}O_4Si_3$ $(M)^+$, 944.3794; found, 944.3750, 944.3780.

$HOSiPCOSi(CH_3)_2(CH_2)_3NC_4H_8S$ Compound XXIV A solution of $CH_3OSi(CH_3)_2(CH_2)_3Cl$, thiomorpholine and CH_3OH was refluxed and the resulting $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8S$ was isolated and distilled. A suspension of this compound, CH_3 SiPcOH and pyridine was partially distilled and the $CH_3SiPcOSi(CH_3)_2(CH_2)_3NC_4H_8S$ formed was isolated and recrystallized. Finally, a mixture of this intermediate, toluene, $(C_2H_5)_3N$ and H_2O was irradiated with light, and the product was isolated, chromatographed and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{41}H_{37}N_9O_2SSi_2$ $(M)^+$, 775.2330; found, 775.2308 775 2310.

$HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_2)_3CH_3)_2$ Compound XXV A solution of $CH_3OSi(CH_3)_2Cl$, $(CH_3(CH_2)_3)_2NH$ and CH_3OH was refluxed and the resulting $CH_3OSi(CH_3)_2(CH_2)_3N((CH_2)_3CH_3)_2$ was isolated. A suspension of this compound, $CH_3SiPcOH$ and pyridine was partially distilled, and the product was isolated and

chromatographed. Finally, a mixture of this intermediate, toluene, $(C_2H_5)_3N$ and H_2O was irradiated with light, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{45}H_{47}N_9O_2Si_2$ $(M+H)^+$, 802.3470; found, 802.3434, 802.3435

HOSiPcOSi$(CH_3)_2(CH_2)_3$NCS Compound XXVI A mixture of $CH_3OSi(CH_3)_2(CH_2)_3Cl$, KNCS and dimethylformamide was warmed and the resulting $CH_3OSi(CH_3)_2(CH_2)_3NCS$ was isolated A mixture of the compound, CH_3SiPcOH and pyridine was partially distilled and the CH_3SiPcOSi$(CH_3)_2(CH_2)_3$NCS formed was isolated, recrystallized and chromatographed. Finally, a solution of this intermediate and toluene was irradiated with light and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{38}H_{29}N_9O_2SSi_2$ $(M)^+$, 731.1704; found, 731.1696, 731.1669.

SiPc[OSi$(CH_3)_2(CH_2)_3NC_4H_8NCH_3]_2$ Compound XXX A suspension of $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$, SiPc$(OH)_2$ and pyridine was partially distilled, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{52}H_{62}N_{12}O_2Si_3$ $(M+H)^+$, 971.4505; found, 971.4460, 971.4489.

HOSiPCOSi$(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$ Compound XXXI A suspension of piperazine, $CH_3(CH_2)_3Br$, toluene and K_2CO_3 was refluxed, and the resulting $HNC_4H_8N(CH_2)_3CH_3$ was isolated and distilled. A solution of this compound, $CH_3OSi(CH_3)_2(CH_2)_3Cl$ and CH_3OH was refluxed, and the $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$ formed was isolated. Next, a suspension of this intermediate, CH_3SiPcOH and pyridine was partially distilled, and the CH_3SiPcOSi$(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$ obtained was isolated and chromatographed. Finally, a mixture of this compound, toluene $(C_2H_5)_3N$ and H_2O was irradiated with light, and the product was isolated and recrystallized: MS-HRFAB exact mass, m/z: calculated for $C_{45}H_{46}N_{10}O_2Si_2$ $(M+H)^+$, 815.3422; found, 815.3424, 815.3423.

SiPc[OSi$(CH_3)_2(CH_2)_3NC_4H_8NH]_2$ Compound XXXII A solution of $CH_3OSi(CH_3)_2(CH_2)_3Cl$, piperazine and CH_3OH was refluxed, and the resulting $CH_3OSi(CH_3)_2(CH_2)_3NC_4H_8NH$ was distilled. A suspension of this compound, SiPc$(OH)_2$ and pyridine was partially distilled and the product was isolated and

recrystallized. MS-HRFAB exact mass, m/z: calculated for $C_{50}H_{58}N_{12}O_2Si_3$ $(M+H)^+$, 943.4192; found, 943.4160, 943.4213.

Preparation of PcIV Salts

$HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2(HCl)$. A mixture of a portion (1.0 mL) of an aqueous solution of HCl (10 N, 25 μL) and MeOH (7.5 mL), EtOH (40 mL), and $HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (25 mg) was stirred for 10 min, evaporated to dryness with a rotary evaporator (room temperature), dissolved in CH_2Cl_2 (1.0 mL), recovered by the addition of MeCN (2.0 mL) and filtration, washed (pentane), chromatographed (Bio Beads SX-3, ethanol), air dried and weighed (17 mG, 67%). UV-vis (EtOH) λ_{max}, nm: 667. ^1H NMR (200 MHz, $CDCl_3$) δ 9.13 (m, 8 H), 8.22 (m, 8 H), 1.83 (d, 6 H), 1.21 (s, 1 H), 1.11 (m, 2 H), -1.19 (m, 2 H), -2.40 (t, 2 H), -3.05 (s, 6 H).

$HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2(CH_3C(O)COOH)$. A mixture of pyruvic acid (4.7 mg), CH_2Cl_2 (26 mL) and $HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$ (12 mg) was stirred for 1 h, evaporated to dryness with a rotary evaporator, washed (MeCN, pentane), vacuum dried (60 °C) and weighed (8 mg, 59 %). UV-vis (EtOH) λ_{max}, nm: 668 ^1H NMR (200 MHz, $CDCl_3$) δ 9.04 (m, 8 H), 8.20 (m, 8 H), 2.08 (s, 3 H), 1.79 (s, 6 H), 1.18 (t, 2 H), -1.31 (m, 2 H), -2.42 (t, 2 H), -3.10 (s, 6 H).

In Vitro Evaluation

Culture of Chinese Hamster V79-379 cells

Chinese hamster V79-379 lung fibroblasts were grown in monolayer culture in McCoy's 5A medium (Gibco Laboratories, Grand Island, N.Y.) augmented with 10% calf serum and buffered with 20 mM HEPES (pH 7.4).

Uptake of Phthalocyanines

Total uptake was determined by scraping the phthalocyanine-treated monolayer, collecting the cells on a glass-fiber filter, and extracting the phthalocyanine in ethanol, as previously described by Ramakrishnan, et al., 1989. (Ramakrishnan, N., M. E. Clay, M. F. Horng, A. R. Antunez, & H. H. Evans, "DNA Lesions and DNA Degradation in Mouse Lymphoma L5178Y Cells After Photodynamic Treatment Sensitized by Chloroaluminum Phthalocyanine", *Photochem. Photobiol*, in press, 1989). The amount of

drug was determined by absorption at 674 nm and expressed relative to the number of cells, as measured in a Coulter cell counter on an aliquot of the cell population. Controls included cells not treated with drug, medium alone, and drug-containing medium without cells. The results of the total uptake of the various compositions of the present invention in comparison to AlPcCl are set forth below in Table 1.

Drug Treatment and Light Exposure

The cells were treated with 1 .mu.M AlPcCl (from Eastman Kodak, Rochester, N.Y.) or with phthalocyanine compositions I-VI (0.5-1.0 .mu.M final concentration in the medium) for 18 hours by adding the appropriate volume of a 1.0 mM stock solution in dimethylformamide (DMF) to the culture medium. The growth medium was replaced with 4 ml Hank's balanced salt solution (HBSS), and the cells were irradiated. The light source was a 500 W tungsten-halogen lamp located approximately 29 inches below the surface of a glass exposure tray. The visible light administered to the cells was filtered to allow passage of only that portion of the visible spectrum above 600 nm (Lee Primary red filter No. 106, Vincent Lighting, Cleveland, Ohio). The fluence rate was approximately 0.074 $kJ/m^2/s$ at the level of the cell monolayer.

Growth Delay

At the time of light exposure, there were approximately 1.5.times.10^5 cells per 25 cm^2 flask. Following irradiation, the HBSS was replaced by 10 ml of fresh complete growth medium, and the cultures were returned to the 37.degree. C. incubator. At various times before and after irradiation, duplicate cultures were trypsinized and counted. Controls included untreated cells and cells treated with light alone or drug alone. In addition, in each experiment, the drug to be tested was compared to a standard treatment, i.e. 1 μM AlPcCl for 18 hours followed by 12 kJ/m^2 light. The results of the growth delay analysis for each of the compositions I-VI in comparison to AlPcCl are set forth in Table 1 below.

Clonogenic Cell Survival

Cells were irradiated at a density of approximately $2x10^6$ per 25 cm^2 flask. Immediately after irradiation, the cell monolayer was treated with trypsin, and

appropriate aliquots were plated in triplicate to give 100 to 200 colonies in each 10-cm Petri dish. Cell survival was determined by the ability of the cells to form colonies containing at least 50 cells. The response of cells treated with 1 μM AlPcCl and light was compared in each experiment.

TABLE 1

Activities of Several Al and Si Phthalocyanines

				Efficiency Relative to 1 μM (AlPcCl)		
Comp.	Structure	Conc. (μM)	Uptake	Growth Delay (12 kj/m^2	F_{10}(AlPcCl)/ F_{10} (Pc)	CF_{10}(AlPcCl)/ CF_{10} (Pc)
	AlPcCl	1.0	1.0	1.0	1.0	1.0
I	$AlPcOSi(CH_3)_2)CH_2)_3N(CH_3)_2$	1.0	2.3	2.1	0.94	0.51
II	$AlPcOSI(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I$	1.0	1.8	3.4	0.99	0.72
III	$CH^3\ SiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_2$	1.0	0.07	0.05	ND	ND
IV	$HOSiPcOsi(CH_3)_2)(CH_2)_3N(CH_3)_2$	0.5 1.0	1.3 1.64	>3 ND	1.85 4.25	3.9 3.5
V	$HOSiPcOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$	1.0	0.3	0	0.59	3.0
VI	$SiPc(OSi(CH_3)_2(CH_2)_3N(CH_3)_3)^+I^-)_2$	1.0	0.1	0.5	ND	ND

Results of Testing Compounds I-VI in V79-379 cell culture

All of the compounds have been examined for the extent of cellular uptake after exposure of V79 cells to 1 .μM or less in complete medium, and the data of Table 1 are presented relative to the uptake from 1 μM AlPcCl, which was 0.723±0.172 nmole/10^7 cells (mean ±S. D., 25 determinations). Compounds I, II, and IV were taken up into the cells more efficiently than was AlPcCl under these conditions. In particular, when the concentration of Compound IV was 1 μM in the medium, the uptake into the cells was sufficiently high that some of the uptake and phototoxicity studies were repeated at 0.5 μM. Compounds III, V, and VI were less effectively incorporated into V79 cells.

Photodynamic action against V79 cells was assessed both by measurement of growth delay and by assay of the loss of clonogenicity. With both assays, none of the compounds showed any dark toxicity at concentrations of 1.0 μM or less for up to 18 hours.

The inhibition of V79 culture growth was measured during a three day period following red light irradiation (12 kJ/m^2) of phthalocyanine-pretreated cells. With each of the active compounds, as well as with AlPcCl, there was an initial decrease in cell density, as dead cells became detached from the monolayer. Thereafter, the cell number per flask increased, as living cells grew and divided. The time for the cell density to

recover to the level at the time of light exposure was considered the growth delay. Cells treated with 1 μM AlPcCl for 18 hours and 12 kJ/m^2 light were used for comparison purposes in each experiment and demonstrated a growth delay of approximately 24 hours. The ratio of the growth delay for the test photosensitizer and the growth delay for AlPcCl measured in the same experiment is recorded in Table 1. There was less inhibition of culture growth when cells were exposed to compounds III, V, or VI as expected from the poor cellular uptake of these drugs. In contrast, substantial inhibition was observed for compounds I, II, and IV. A value of >3 for compound IV (Table 1) indicates that the cell density had not recovered to the initial level during the three day observation period.

Photocytotoxicity of the phthalocyanines compounds I to VI was also assessed by clonogenic assay (Table 1, FIG. 1). In all experiments, 1 μM AlPcCl was included for comparison purposes. From the survival curves (FIG. 1), the fluence reducing the cell survival to 10% (F_{10}) was obtained. The ratio of the F_{10} for AlPcCl and the F_{10} for the test compound is recorded in Table 1. Compounds I and II appear to be nearly as efficient photosensitizers as AlPcCl, while compound IV (assayed at half the concentration) was almost twice as efficient as the standard AlPcCl. Clonogenic assays were not conducted for compounds III and VI, since the data on uptake and growth delay suggested that these compounds would have poor activity. However, in spite of the low efficiency of compound V in inhibiting cell growth, survival measurements were made for this compound, because it was taken up into V79 cells somewhat more efficiently than compounds III and VI.

In order to take differences in cellular uptake into consideration in the assessment of the relative efficiency of these phthalocyanines as photosensitizers of V79 cells, the survival data were replotted against the product of intracellular phthalocyanine concentration and light fluence (FIG. 2). From these curves, the product of intracellular concentration and light fluence reducing survival to 10% (CF_{10}) was obtained, and comparisons of the values for AlPcCl and the test compounds are recorded in Table 1. By this and the other criteria, compound IV appears to be the most efficient photosensitizer. However, when consideration is given to the lesser cell uptake of compound V, it appears to be about as strong a photosensitizer as compound IV.

Discussion of Testing Compounds I-VI in V79 Cell Culture Photocytotoxicity

The low activity of compounds III and VI appears to be due to poor cell uptake. Both of these compounds have functional groups on both faces of the phthalocyanine ring, and it is possible that one face of the ring must be free for proper interaction with target biomolecules. Either Si phthalocyanine with no more than a hydroxyl group on one face (IV) or Al phthalocyanine with one face free of substituents (I and II) allows efficient cellular uptake as well as a high degree of cellular inactivation. Thus, both tertiary and quaternary amines appear to be efficacious structures. Compound V is an anomaly. Although it has features on either face of the phthalocyanine ring found on active molecules, the combination appears not to allow efficient cellular uptake. However, that which is incorporated into the cells has good photodynamic activity.

The results of the in vitro biological tests of the new phthalocyanines compounds I to VI are an important introduction to the design of a new class of photosensitizers. The results suggest that tertiary and quaternary amines may be an important class of structures to be explored. The axial ligands of the series of compounds listed in Table 1 are simpler than the corresponding ligand of the original diethylamine which served as a prototype. The simpler ligands appear to have the advantages of stability in solution, making them easier to study. The instability of the diethylamine precluded precise measurements of the concentration of the active species at the time of irradiation. Therefore, the true photosensitizing activity of the prototype compound may also be high.

Evaluation and Uptake of Phthalocyanine Compounds VII-XV, XVII-XIX, XXI-XXVIII, and XXX-XXXII

In addition to the phthalocyanine compounds I to VI, several other new phthalocyanine compounds have proven to be effective in treating cancer. V79 cells Chinese hamster lung fibroblasts were cultured using the cell culture methods described above. The phthalocyanines listed in table 2 were added to the cultures typically at concentrations of 1 μM, 2 μM, and/or 4 μM and incubated for 18 hours, after which aliquots of the cells were counted and other aliquots were collected on a glass fiber filter. When the filters were dry, the phthalocyanines were extracted into ethanol and the absorption determined at the peak wavelength, usually 668 nm. Values were converted to

nmoles taken up by 10^6 cells, using an extinction coefficient of 2.93.times.10^5. The cellular uptake of the phthalocyanines are presented in Table 2.

TABLE 2

Uptake of Additional Phthalocyanines Into V79 Cells

Pc	n Moles/10^6 cells			n Moles/ 10^6
Num.	1 µM	2 µM	4 µM	Cells/µM
IV	0.7 ± 0.2	3.1 ± 0.3	4.6 ± 2.9	1.1
VII	0.2 ± 0.03		1.1 ± 0.5	0.2
VIII	0.1 ± 0.04		0.8 ± 0.01	0.2
IX	0.1 ± 0.1		1.8 ± 0.8	0.3
X	0.6 ± 0.2		3.3 ± 1.4	0.7
XI	0.1		0.3 ± 0.1	0.1
XII	2.1 ± 1.2		4.6 ± 1.5	1.6
XIII			1.7 ± 0.3	0.4
XIV	0.03 ± 0.01		0.05 ± 0.01	<0.05
XV	0.01 ± 0.01		0.14 ± 0.12	<0.05
XVI	0.2 ± 0.2		0.7 ± 0.20	0.2
XVII			1.7 ± 0.2	0.4
XVIII	0.3 ± 0.1		3.6 ± 0.6	0.3*
XIX	0.3 ± 0.1		2.4 ± 0.5	0.3*
XXI	1.2 ± 0.2		5.8 ± 0.4	1.3
XXII				ND
XXIII				ND
XXIV	0.003 ± 0.001		1.3 ± 0.1	<0.05*
XXV	0.02 ± 0.02		1.5 ± 0.3	<0.05*
XXVI				ND
XXVII	1.8		5.0 ± 0.01	1.5
XXVIII	1.2 ± 0.2	3.6 ± 1.0	11.4 ± 0.05	1.2*
XXX				ND
XXXI		0.61 ± 0.1		0.3

In the last column, wherever possible, a composite value was calculated, in order to have a single number for the purposes of ranking the uptake efficiency of the compounds. For most compounds, the average of all the data has been calculated and rounded to the first decimal. Where all values are <0.05, the data are presented as <0.05. An asterisk (*) indicates that an average uptake value, which is the average of the phthalocyanine doses would be higher than the listed value which is for 1 µM.

It appears from Table 2 that the uptake of PcXVIII, PcXIX, PcXXIV, PCXXV, and PcXXVIII are not linearly dependent upon the phthalocyanine concentration in the medium. PcIV, PcXII, PcXXI, PcXXVII and PcXXVIII are taken up particulary well by the V79 cells.

Clonogenicity studies using Phthalocyanine Compounds VII-XV, XVII-XIX, XXI-XXVIII, and XXX-XXXII into V79 Cells

Using the cell culture methods described above, V79 cells Chinese hamster lung fibroblasts were treated with either 0.5 or 1.0 μM of the phthalocyanines listed in Table 3. About 18 hours thereafter, the cells were irradiated with increasing doses of 675 nm broad band red light from a 500 W tungsten-halogen lamp fitted with a 600 nm high pass filter, to determine the light dosage that would kill 90% of the phthalocyanine treated cells. Where 90% of the cells were not killed, the maximum percent of cells killed were determined, (expressed as % survival) and the related light dosage recorded. The results are presented in Table 3.

TABLE 3

EVALUATION OF PHTHALOCYANINE COMPOUNDS IN KILLING V79 CELLS USING PHOTODYNAMIC THERAPY

Pc	Concn μM	LD 90 (kj/m^2	Maximum Effect (% survival at kj/m^2)	n Moles/10^6 cells/μM (from Table 2)
IV	0.5	4		1.1
VII#	0.5	4		0.2
VIII	1		94% at 30	0.2
IX	0.5		44% at 9	0.3
X	0.5	7		0.7
XI	1		100% at 20	0.1
XII	0.5	3.3		1.6
XIII	1		88% at 15	0.4
XIV	1		93% at 10	<0.05
XV	4		81% at 20	<0.05
XVI	4		100% at 10	0.2
XVII	1		19% at 10	0.4
XVIII	1	7		0.3*

XIX	1		81% at 10	1.3
XXI	0.5	15*		ND
XXII	0.5	10		ND
XXIV	0.5		100% at 10	<0.05*
XXV	0.5		87% at 8	<0.05*
XXVI	1		100% at 30	ND
XXVII	0.5	6.8		1.5
XXVIII	0.5	1.8		1.2*
XXX			30% at 10	ND
XXXI	0.5		30% at 10	0.3

*not totally soluble at 0.5 mM
#Preplated data only

As shown in Table 3, PcIV, PcVII, PcXII, and PcXXVIII achieved the LD 90 at the lowest light dosage, and thus are the most active photsensitizers, that is they are the most active at killing V79 cells.

For comparison, the phthalocyanine uptake values presented in Table 2 were also presented in the last column of Table 3. As shown in Table 3, some, but not all, of the differences in photosensitizing activity among phthalocyanines can be explained by differences in uptake. For example, PcXXVIII which has the highest activity in killing V79 cells of all of the phthalocyanines also has a high uptake. The uptake of Pc XXVIII at 1 μM is less than that for PcXII, whereas its photodynamic killing efficiency is superior to PcXII when analyzed at 0.5 μM.

It is not surprising that often phthalocyanines with poor uptake are relatively less active in photodynamic therapy, whereas the most active phthalocyanines demonstrate a relatively high uptake. However, uptake and activity are not always correlated. For example, PcVII has poor uptake but one of the better photosensitizers. PcXIX has poor uptake but is less active as a photosensitizer, whereas PcXVIII, with similar uptake, demonstrated good activity. Many factors contribute to determination of the photosensitizer efficiency, including physical state in the cells and localization.

Assessment of Photodynamic Efficiency of Additional Phthalocyanines in L5178Y-R Cells

Mouse lymphoma L5178y-R (hereinafter also referred to as "LY-R") cells were grown in suspension culture as described in Ramakrishnan N., Oleinick, N. L. Clay, M. E., Horng, M. F., Antunez, A. R., and Evans H. H., DNA lesions and DNA degradation

in mouse lymphoma L5178Y cells after photodynamic treatment sensitized by chloroaluminum phthalocyanine. Photochem. Photobiol. 50, 373-378, 1989 and Agarwal, M. L., Clay, M. E., Harvey, E. J., Evans, H. H., Antunez, A. R., and Oleinick, N. L. Photodynamic therapy induces rapid cell death by apoptosis in L5178Y mouse lymphoma cells. Cancer Res., 51, 5993-5996, 1991.

The cells were used while in exponential growth. Stock solutions of either 0.5 or 1 mM of PcIV, PcXII, PcX, PcXVIII were prepared in dimethylformamide unless otherwise indicated and added to the 10 mL medium at a rate of 1 .μL per mL. After allowing 18 hours for uptake of the phthalocyanine into the cells, the flasks containing the cultures were placed on a glass exposure tray above a 500-W tungsten-halogen lamp. The exposure tray was fitted with a 600-nm high-pass filter. Flasks were exposed to various fluences of red light (up to 30 kJ/m^2) at a fluence rate of approximately 74 W/m^2). After irradiation, the cells were collected by centrifugation.

For measurement of clonogenic cell survival, aliquots were plated in medium containing soft agar as described in Ramakrishnan N., Oleinick, N. L. Clay, M. E., Horng, M. F., Antunez, A. R., and Evans H. H., DNA lesions and DNA degradation in mouse lymphoma L5178Y cells after photodynamic treatment sensitized by chloroaluminum phthalocyanine. Photochem. Photobiol. 50, 373-378, 1989. The aliquots were plated in sufficient numbers to produce 50-200 colonies. The dishes were kept in an incubator at 37° C. in an atmosphere of 5% CO_2 and 95% air for 10-14 days to allow viable cells to form colonies. Colonies were counted by eye. Controls treated with the phthalocyanine alone had plating efficiencies of about -90%. The plating efficiencies of the treated cells are normalized to the plating efficiencies of control cells in each experiment. For measurement of the induction of apoptosis, DNA was isolated from the treated and control cells 2 hours after photodynamic therapy, subjected to electrophoresis on 1.5% agarose, stained with ethidium bromide, and visualized by UV transillumination, as described in Agarwal et al. The results are shown in Tables 4, 5 and 6 and in FIG. **3**.

TABLE 4

Comparison of Different Phthalocyanine Compounds
In PDT-treated LY-R cells

LIGHT DOSE	Pc IV	Pc XII	Pc X	Pc XVIII

(kJ/m^2)	AVG.	SD	AVG.	SD	AVG.	SD	AVG.	SD
0	100		100		100		100	
1	80.9	11.4	82.2	8.6				
2	19.7	2.9	5.23	0.86	71.8	15.4	81.8	6.0
2.5	0.82	0.09	0.90	0.15				
3	0.16	0.10	0.15	0.01	30.1	3.7	73.6	4.8
4			0.014	0.002	20.5	1.1	64.0	7.0
5	0.014	0.001	0.0027	0.0008	0.43	0.19	52.1	6.2
6					0.031	0.014	33.8	5.8
8					0.00058	0.0003	9.13	1.52
10							3.0	3.0

In Table 4 each phthalocyanine was present at 0.5 .μM, and the normalized plating efficiencies are presented as mean and standard deviation at each fluence tested. The results show that all four phthalocyanines are active photosensitizers for photodynamic therapy. Based on their relative ability upon irradiation with various fluences of red light to reduce tumor cell survival, these phthalocyanines are ranked from the most active photosensitizers to the least active: PcIV, PcXII, PcX, PcXVIII. This relative activity of these four phthalocyanines is the same as obtained from screening in V79 cells.

FIG. 3 shows the average plating efficiencies from Table 4 plotted against the fluence for each Pc.

TABLE 5

Clonogenic Assay of Phthalocyanines

Pc	Concentration (μM)	Ld_{50} (kJ/m^2)	Ld_{90} (kJ/m^2)
Pc IV	0.5 μM	1.38	2.15
Pc X	0.5 μM	2.38	4.19
Pc XII	0.5 μM	1.11	1.70
Pc XVIII	0.5 μM	5.00	7.81

Table 5 shows the fluence that reduces the cell survival to 50% and to 10% and which are given as LD_{50} and LD_{90}, respectively. The most active compound of the phthalocyanines shown in Table 5 is PcXII. PcXII when present in the culture medium at 0.5 .μM requires less light, that is the lowest fluence, to kill either 50% or of the cells. PcIV is about 80% as active as PcXII, PcX is 44% as active as PcXII and PcXVIII is 22% as active as PcXII.

TABLE 6

Relative Capacity of Phthalocyanines to Induce Apoptosis

	Minimum Demonstrated Condition		
Pc	Concentration (μM)	Fluence (kJ/m^2)	C x F Ld_{90} (kJ/m^2)
Pc IV	0.4	3.0	1.2
Pc VII	0.5	3.0	1.5
Pc IX	0.3	12.0	3.6
	0.5	8.0	4.0
	1.0	12.0	12.0
Pc X	0.5	6.0	3.0
	1.0	3.0	3.0
Pc XII	0.4	3.0	1.2
Pc XVIII	0.5	10.0	5.0
	1.0	3.0	3.0
Pc XXII	0.5	10.0	5.0
PcXXVIII	0.3	3.0	0.9
PcXXX (DMF-Tween 80)	0.5	15.0	7.5
Pc XXXII (DMF-Tween 80)	0.5	5	2.5

Table 6 shows that photodynamic therapy with the phthalocyanine compounds listed causes L5178Y cells to undergo apoptosis as the mode of cell death. Cells were treated with various concentrations of the compounds listed in the table and various light fluences. DNA gels were prepared and examined for the characteristic "ladder" pattern of DNA fragments. For each Pc, the minimum total PDT dose tested (calculated as the product of the minimum phthalocyanine concentration and the minimum fluence) which produced visible DNA fragments is recorded. PcXXX and PcXXXII were not soluble in

DMF and were suspended and partially solubilized in DMF/Tween 80 for this assay. PcIX is unusual in that its activity increases and then decreases as the concentration is raised. PcX was added at concentrations of 0.5 and 1.0 μM; the same minimum value for the C.times.F product was obtained in both cases. PcXVIII was also added at 0.5 and 1.0 μM. The minimum value of CxF differed only slightly for the two conditions. PcV, PcVI, PcVIII, PcXI, PcXIV and PcXV, when evaluated at a concentration of 1 μM at a fluence of 30 kJ/m^2 did not induce apoptosis. Compound PcXVI at a concentration of 4 μM and a fluence of 20kJ/m^2 for 2 hours did not induce apoptosis.

In vivo Evaluation of Phthalocyanine Compounds VII-XV, XVII-XIX, XXI-XXVII, and XXX-XXXII

The relative effectiveness at reducing tumor volume of selected phthalocyanine compounds at a given dosage was compared in vivo. RIF-1, i.e., radiation-induced fibrosarcoma, tumors were implanted into the backs of C3H/HeN mice. One tumor was implanted per mouse. Each of the phthalocyanine compounds listed in Table 7 was sonicated and vortexed in corn oil to produce a suspension. When the tumors reached 5-7 cm in diameter and 2-3 mm in thickness, each mouse received 1 mg/kg in 0.1 ml of the corn oil, of the phthalocyanine suspension. For comparison, select mice received a conventional photosensitizer; either 5 mg/kg of chloroaluminum phthalocyanine tetrasulfonate, herein also referred to as "AlPcTS" in phosphate buffered saline or 5 mg/kg of Photofrin®.-II in 5% dextrose. Twenty-four hours after the photosensitizers were administered, the tumors were irradiated with visible radiation delivered by an argon-pumped dye laser. The mice that received a phthalocyanine photosensitizer received light having a wavelength of 675 nm and the mice that received the Photofrin® II photosensitizer received light having a wavelength of 630 nm. Each tumor received 135 J/cm^2 of radiation. Tumor size was measured every day using calipers. The initial tumor volume was 50±10 mm^3. Tumor volume was calculated according to the hemiellipsoid model by the formula:

$V = 1/2 \quad (4\pi)/3 \text{ x } (1/2 \text{ x } (w/2)) \text{ x } h$

Where l is length

Where W is width

Where H is height

The tumor response is shown in Table 7.

TABLE 7

Comparative Responses of RIF-1 Implanted Tumors to PDT With Selected Phthaocyanine Compounds

Photosensitizer	Tumor Responses at 24 hours	Doubling Time of Initial Tumor Volume after PDT in days
Pc XXXVIII	complete	24
Pc XII	complete	20
Pc IV	near complete	16
Pc XVIII	near complete	12
Pc IX	near complete	11
Pc V	moderate	6
Pc VIII	slight	4
AlPcTS*	substantial	7
Photofrin ™-II	near complete	12
controls		4

complete - no evidence of any tumor mass in any animal; only the scar from the photodynamic therapy was evident.
near completen - evidence of any tumor mass in four or five animals; only some - tumor mass in one or two animals.
substantial - a significant tumor shrinkage occurred in all animals. In some animals the tumor response was complete, yet in others the response was not complete.
moderate - some tumor shrinkage was evident in some animals. In animals wit some tumor shrinkage, scar formation was evident.
slight - some tumor decrease occurred in one or two mice.

While the tumor volume in the control mice doubled in four days, the doubling of tumor volume was delayed in the animals treated with each of the compounds except PcVIII. PcXXVIII, PcXII, PcIV, PcXVIII, PcIX were particularly effective in reducing tumor volume.

Histological examination of tumors treated with PcIV revealed the presence of apoptotic bodies in the tumor. Analysis of tumors treated with Pc IV showed DNA fragments whose sizes were multiples of 180-200 base pairs.

As can be seen from Table 7, Pc XXVIII, Pc XII and Pc IV significantly impair the growth of the tumors and are the most preferred photosensitizers for the treatment of cancer, because of effectiveness at set dosage of phthalocyanine.

Not only do the phthalocyanine compounds of the present invention reduce tumor volume, they are capable of eliminating tumors completely particularly upon multiple exposures to radiation.

Complete inhibition of tumors by PDT with PcIV

As occurs with PF-II-PDT, regrowth of tumors from the tumor margins occurred in the animals treated Pc IV, followed by the exposure to light. This regrowth possibly originates from the cells which somehow escape irradiation.

To overcome the regrowth, RIF-1 tumors were implanted in C3H/HeN mice, and the mice were treated with PcIV followed by multiple exposures to light. For multiple exposures to light to be successful, the tumor tissue must retain sufficient levels of the photosensitizer over the exposure period.

Since pharmacokinetic data indicated that Pc IV is retained in tumor tissue even after 7 days of its administration, Pc IV was administered once at the dose of 1 mg/kg body weight in corn oil or entrapped in DPPC liposomes. Thereafter, the tumors were irradiated with an argon ion pumped dye laser tuned at 675 nm for the total light dose of 135 J/cm^2 (75 mW/cm^2). The tumors were irradiated with multiple exposures of 675 nm laser light, at varying times, as shown in Table 8.

TABLE 8

Responses of RIF-1 implanted tumors to PcIV followed by multiple exposures to light

day of exposure	% of Mice Surviving		
	corn oil 15 days	liposomes 30 days	liposomes 120 days
2	100	100	N/A
2 and 3	100	100	N/A
2, 3, and 4	100	0	0
2, 3, 4, 5, and 6	100	0	0
2-6	100	0	0
2 and 7	100	100	N/A

Where Pc IV was given in corn oil, regrowth of tumors was evident 15 days after photodynamic therapy in all the multiple exposure protocols. However, when the PcIV was administered entrapped in DPPC liposomes, complete tumor cure was evident in those mice which were irradiated three, four or five times at an interval of 24 hours. No tumor regrowth occurred even at 120 days after the photodynamic therapy. Indeed, at the time the mice were sacrificed 300 days after the light treatment, there was no evidence of tumor regrowth. Tumor regrowth occurred 30 days after photodynamic therapy only in those animals which were irradiated only one or two times either at 24 or 120 hour intervals. One reason for this differential effect may be related to the pharmacokinetics of

the dye, that is the dye may have been retained in the tissue for a long period which permitted multiple exposures to be effective. Alternatively, the administration of Pc IV, via DPPC liposomes may enhance uptake and retention of PcIV by the tumor cells.

Treatment of chemically induced skin tumors.

6-week-old female SENCAR mice received a single topical application of 5 μg DMBA in 0.2 ml acetone on the dorsal skin as tumor initiator. One week later, the animals were started on twice-weekly topical applications of 1 μg TPA in 0.2 ml acetone as tumor promoter. All of the animals developed tumors at 12 weeks. Mice that developed 4-5 tumors per animal averaging 5-8 mm in diameter and 2-5 mm in thickness were used. Pc IV, entrapped in DPPC liposomes was administered intraperitoneally at doses of either 0.5 or 1.0 mg/kg and 24 hrs later the tumor area was illuminated with light from an argon pumped dye laser tuned at 675 nm for a total light dose of 135 J/cm^2 (75 mW/cm^2). All possible controls were included; either the animals were untreated, treated only with laser light or treated only with Pc IV alone.

Curves for animals after PDT with Pc IV at the doses of 0.5 and 1.0 mg/kg are shown by d and e in Figure 4. As shown in FIG. 4 the mice treated with PcIV and light showed a decrease in tumor volume which eventually decreased to 0 volume, that is, no tumor was measurable. The tumor did not return for the length of the study, 34 days. In contrast, the control tumor volume consistently increased over time.

Comparison of Uptake of PcIV and PcIV-Salts into Human Cancer Cells

The PcIV salts (PcIV-pyruvate and PcIV-hydrochloride) were compared to PcIV, with respect to their ability to be taken up into human breast cancer MCF-7c3 cells *in vitro*.

Cells were grown in 5 mL of RPMI-1640 medium supplemented with 10% fetal calf serum in 60-mm diameter Petri dishes in a 37 °C incubator in an atmosphere of 5% CO_2, 95% air. Cultures were used when they were in exponential growth. For experiments, various concentrations (50, 100 or 200 nM) of each compound (PcIV, PcIV-HCl, PcIV-pyruvate), were added to the medium above the cells, and the dishes were returned to the incubator for 60 minutes to allow the photosensitizers to enter the cells.

To evaluate uptake, the medium was removed, and the cells were detached from the plastic surface with trypsin and collected by centrifugation. The cell pellet was suspended in phenol-red-free Hank's balanced salt solution and analyzed by flow cytometry (λex = 335-355 nm; emission collected through a 650-nm long-pass filter). For each cell sample, the data were expressed as the mean channel fluorescence and background was subtracted. Data for each concentration of the PcIV salts were then normalized to those for the same concentration of PcIV in the same experiment. In Figure 5, data for 50 and 100 nM are single observations for each photosensitizer, whereas data for 200 nM are presented as the mean normalized values for three experiments. Error bars represent the standard deviation of the mean. The data show that the PcIV salts are at least as efficient, and possibly more efficient, in entering MCF-7c3 cells.

Successful Penetration of Topically-applied PcIV and PcIV Salts into Human Skin

Human skin absorption of PcIV was analyzed by fluorescence confocal microscopy. PcIV fluorescence, upon activation with a HeNe laser at 633 nm, was visualized using a 650 long pass filter. Briefly, 0.4 mm thick human keratomes were removed from the gluteal region of healthy volunteers and divided into 1.5 cm x 1.5 cm squares of skin. Upon application of PcIV to the epidermis in a vehicle of ethanol and propylene glycol, visualization of penetration of PcIV was achieved by fluorescence. Pc 4 was then prepared as PcIV-pyruvate and PcIV-HCl and applied in the same vehicle as Pc 4 to the epidermis. Three concentrations, namely, 0.1 mg/ml, 0.05 mg/ml, 0.01 mg/ml were tested per PcIV formulation. Skin was incubated at 37 °C for 1, 2 and 4 hours, along with vehicle controls. Confocal analysis of each of the three formulations revealed PcIV fluorescence in membrane or peripheral cytoplasmic patterns on stratum granulosum keratinocytes with cytoplasmic pattern in the basal layer. Maximum Pc 4 fluorescence was detectable using laser transmission of 3% for the 0.1 mg/ml and 30% for the 0.01 mg/ml. Both PcIV-pyruvate and PcIV-HCl however could be visualized with a laser transmission of 2-3% for the 0.1 mg/ml and 7-9% for the 0.01 mg/ml concentrations. Because fluorescence was inversely proportional to the laser transmission at a constant laser gain, it was determined that PcIV successfully penetrated the skin to the basal layer in a dose dependent fashion, and that the salts may have enhanced penetration capacity for development as a topical PDT drug for epithelial cancers.

Evaluation of the penetration of topically applied PcIV and PcIV salts into the skin via confocal fluorescence microscopy

The ability of PcIV and the newly prepared PcIV salts (HCl and pyruvate) to penetrate into the epidermis of keratome derived biopsies was examined. The time course of penetrance as well as the effect of dose of the PcIV compounds were evaluated. PcIV and the PcIV-HCl and PcIV-pyruvate salts were resuspended in ethanol (100%, 1 part PcIV, 499 parts ethanol) and then diluted to final concentrations in a 30% Propylene Glycol 70% Ethanol mixture.

Keratome biopsies of normal skin were obtained from normal volunteers after written consent according to UHHS IRB protocol # 05-95-03. To date, seven experiments have been performed. The range of age for volunteers was 20-40 yrs. Individuals represented Fitzpatrick skin types between I-III. Skin biopsies were held in PBS following the keratome procedure until processed for PcIV Application (less than 1hr). The keratome skin samples (1.5 cm^2) were overlayed onto sterile gauze in 80mm tissue culture petri dishes epidermal side down. PcIV compounds were then applied to the corners of the sterile gauze and allowed to "wick" through the gauze and contact the epidermis of the skin for the indicated times. Following the incubation, the tissue was removed from the gauze and washed three times in phosphate buffered saline and held, in PBS, until analysis by confocal microscopy. Confocal images were acquired using a 20X N.A. 0.5 water immersion objective on a Zeiss 510 confocal microscope. PcIV fluorescence was elicited using a 633nm wavelength for excitation, and collected with a 633nm dichroic mirror and 650nm long-pass filter.

Results: PcIV fluorescence shown in vertical cross section (FIG. 6a), and *en face* horizontal optical sections (FIG. 6b). PcIV fluorescence was measured 1hr following application to the keratome biopsy. Negative control, skin only plus exposure to vehicle, showed no autofluorescence using this detection protocol (FIG. 6c)

In order to assess the penetration of PcIV over time, a time course of PcIV uptake was evaluated. Keratome biopsies prepared as described above were exposed to PcIV for

either 1h (FIG. 7a), 2h (FIG. 7b) or 4h (FIG. 7c). A representative horizontal section (2h) is also shown (FIG. 7d).

Finally, the PcIV salts were compared to PcIV to assess uptake of the new compounds. PcIV (FIG. 8a) was compared to PcIV-pyruvate (FIG. 8b) and PcIV-HCl (FIG. 8c) for penetrating into the epidermis of keratome biopsies prepared as previously described. Cross sections of PcIV (FIG. 8d), PcIV-pyruvate (FIG. 8e) and PcIV-HCl (FIG. 8f) are also shown.

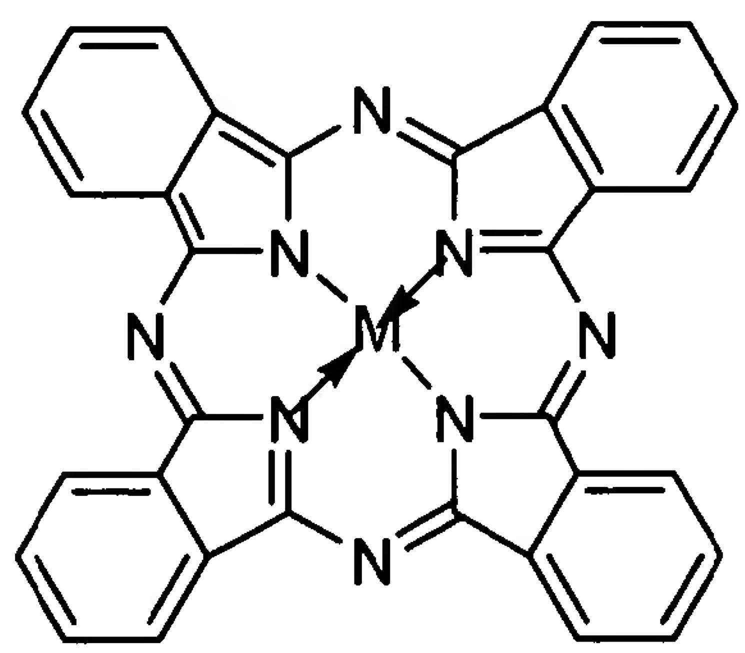
Conclusion: effective penetration of PcIV through intact human stratum corneum is achieved within one hour. Penetration in the propylene glycol vehicle is demonstrated at the lowest concentration tested (0.01mg/ml). Modifications of the PcIV compounds by formulation as a salt (PcIV-HCl) or (PcIV-pyruvate) does not hinder the penetration of the compound through the skin.

The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

We Claim:

1. A pharmaceutical composition for topical administration, comprising a phthalocyanine photosensitizer or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

2. A pharmaceutical composition of claim 1, wherein the phthalocyanine has a structure of Formula I or a pharmaceutically acceptable salt thereof



(I)

wherein M is $(G)_a Y[(OSi(CH_3)_2 (CH_2)_b N_c (R')_d (R'')_e)_f X_g]_p$

Y is selected from Si, Al, Ga, Ge, or Sn;

R' is selected from H, C, CH_2, CH_3, C_2H_5, C_4H_9, C_4H_8NH, C_4H_8N, $C_4H_8NCH_3$, C_4H_8S, C_4H_8O, C_4H_8Se, CH_2CH_3, $(CH_2)_3(CH_3)_2$, $OC(O)CH_3$, $OC(O)$, $(CH_3)_2(CH_2)_{11}$, CS, CO, CSe, OH, $C_4H_8N(CH_2)_3CH_3$, $(CH_2)_2N(CH_3)_2$, $C(O)C_{27}H_{30}N_2O$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

R'' is selected from H, SO_2CH_3, $(CH_2)_2N(CH_3)_2$, $(CH_2)_{11}CH_3$, $C(S)NHC_6H_{11}O_5$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

G is selected from OH, CH_3, and $(CH_3)_3C(CH_3)_2$;

X is selected from I, F, Cl, or Br;

a is 0 or 1;

b is an integer from 2 to 12;

c is 0 or 1;

d is an integer from 0 to 3;

e is an integer from 0 to 2;

f is 1 or 2;

g is 0 or 1;

n is an integer from 1 to 12;

o is an integer from 1 to 11; and

p is 1 or 2.

3. A pharmaceutical composition of claim 2, wherein M is selected from $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $CH_3SiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-]_2$; $Si[OSi(CH_3)_2(CH_2)_4NH_2]_2$; $Si[OSi(CH_3)_2(CH_2)_4NHSO_2CH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_4\ NHCSNHC_6H_{11}O_5]_2$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3OCOCH_3$; $Si[OSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3]_{22}I^-$; $(CH_3)_3C(CH_3)_2SiOSiOSi(CH_3)_2(CH_2)_4NCOC_{27}H_{30}N_2O$; $HOSiOSi(CH_3)_2(CH_2)_3OH$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8O$; $AlOSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3I^-$; $HOSiOSi(CH_3)_2(CH_2)_8N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8O]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8S$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2)_3(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3NCS$; $HOSiOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$; or $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NH]_2$.

4. A pharmaceutical composition of claim 3, wherein M is $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$.

5. A pharmaceutical composition of claim 4, wherein the phthalocyanine of Formula I is formulated as a salt selected from hydrobromide, hydrochloride, sulfate, bisulfate, phosphate, nitrate, acetate, pyruvate, valerate, oleate, palmitate, stearate, laurate, benzoate, lactate, phosphate, tosylate, citrate, maleate, fumarate, succinate, tartrate, naphthylate, mesylate, glucoheptonate, lactobionate, and laurylsulphonate salts

6. A pharmaceutical composition of claim 5, wherein the phthalocyanine of Formula I is formulated as a salt selected from hydrochloride and pyruvate.

7. A pharmaceutical composition of claim 6, wherein the phthalocyanine of Formula I is formulated as a hydrochloride salt.

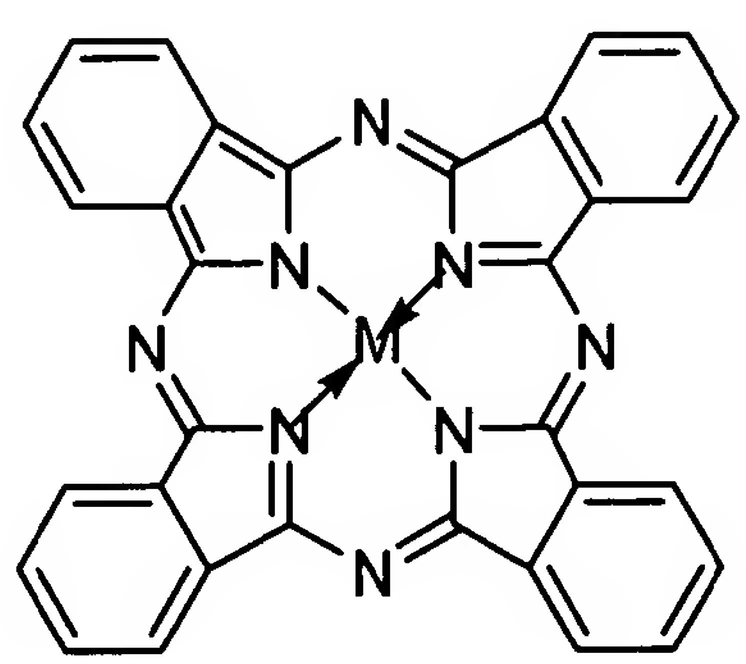
8. A pharmaceutical composition of claim 7, wherein the phthalocyanine of Formula I is formulated as a pyruvate salt.

9. A method for treating epithelial cancer, comprising
(i) topically administering a photosensitizer to an area of skin
(ii) irradiating the skin.

10. A method of claim 9, further comprising a pharmaceutically acceptable carrier.

11. A method of claim 10, wherein the photosensitizer is a phthalocyanine or a pharmaceutically acceptable salt thereof.

12. A method of claim 11, wherein the phthalocyanine has a structure of Formula I or a pharmaceutically acceptable salt thereof



(I)

wherein M is $(G)_a\, Y[(OSi(CH_3)_2\, (CH_2)_bN_c(R')_d\, (R'')_e)_f\, X_g]_p$
Y is selected from Si, Al, Ga, Ge, or Sn;
R' is selected from H, C, CH_2, CH_3, C_2H_5, C_4H_9, C_4H_8NH, C_4H_8N, $C_4H_8NCH_3$, C_4H_8S, C_4H_8O, C_4H_8Se, CH_2CH_3, $(CH_2)_3(CH_3)_2$, $OC(O)CH_3$, $OC(O)$, $(CH_3)_2(CH_2)_{11}$, CS,

CO, CSe, OH, $C_4H_8N(CH_2)_3CH_3$, $(CH_2)_2N(CH_3)_2$, $C(O)C_{27}H_{30}N_2O$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

R" is selected from H, SO_2CH_3, $(CH_2)_2N(CH_3)_2$, $(CH_2)_{11}CH_3$, $C(S)NHC_6H_{11}O_5$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

G is selected from OH, CH_3, and $(CH_3)_3C(CH_3)_2$;

X is selected from I, F, Cl, or Br;

a is 0 or 1;

b is an integer from 2 to 12;

c is 0 or 1;

d is an integer from 0 to 3;

e is an integer from 0 to 2;

f is 1 or 2;

g is 0 or 1;

n is an integer from 1 to 12;

o is an integer from 1 to 11; and

p is 1 or 2.

13. A method of claim 12, wherein M is selected from $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $CH_3SiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-]_2$; $Si[OSi(CH_3)_2(CH_2)_4NH_2]_2$; $Si[OSi(CH_3)_2(CH_2)_4NHSO_2CH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_4NHCSNHC_6H_{11}O_5]_2$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3OCOCH_3$; $Si[OSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3]_2 2I^-$; $(CH_3)_3C(CH_3)_2SiOSiOSi(CH_3)_2(CH_2)_4NCOC_{27}H_{30}N_2O$; $HOSiOSi(CH_3)_2(CH_2)_3OH$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8O$; $AlOSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3I^-$; $HOSiOSi(CH_3)_2(CH_2)_8N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8O]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8S$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2)_3(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3NCS$; $HOSiOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$;

$Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$; or $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NH]_2$.

14. A method of claim 13, wherein M is $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$.

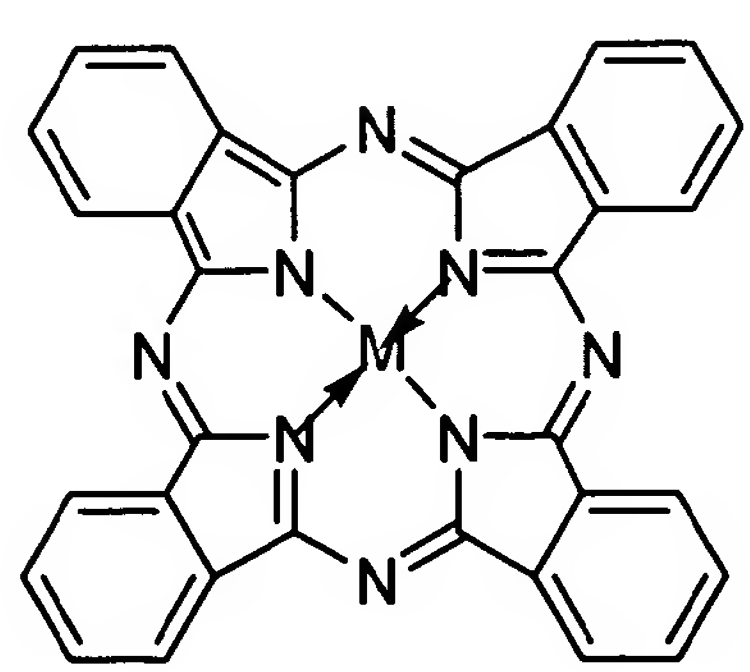
15. A method of claim 12, wherein the phthalocyanine of Formula I is formulated as a salt selected from hydrobromide, hydrochloride, sulfate, bisulfate, phosphate, nitrate, acetate, pyruvate, valerate, oleate, palmitate, stearate, laurate, benzoate, lactate, phosphate, tosylate, citrate, maleate, fumarate, succinate, tartrate, naphthylate, mesylate, glucoheptonate, lactobionate, and laurylsulphonate salts

16. A method of claim 15, wherein the phthalocyanine of Formula I is formulated as a salt selected from hydrochloride and pyruvate.

17. A pharmaceutical composition of claim 16, wherein the phthalocyanine of Formula I is formulated as a hydrochloride salt.

18. A method of claim 16, wherein the phthalocyanine of Formula I is formulated as a pyruvate salt.

19. A pharmaceutically acceptable salt of a compound having the structure of Formula I



(I)

wherein M is $(G)_a\, Y[(OSi(CH_3)_2\, (CH_2)_bN_c(R')_d\, (R'')_e)_f\, X_g]_p$

Y is selected from Si, Al, Ga, Ge, or Sn;

R' is selected from H, C, CH_2, CH_3, C_2H_5, C_4H_9, C_4H_8NH, C_4H_8N, $C_4H_8NCH_3$, C_4H_8S, C_4H_8O, C_4H_8Se, CH_2CH_3, $(CH_2)_3(CH_3)_2$, $OC(O)CH_3$, OC(O), $(CH_3)_2(CH_2)_{11}$, CS, CO, CSe, OH, $C_4H_8N(CH_2)_3CH_3$, $(CH_2)_2N(CH_3)_2$, $C(O)C_{27}H_{30}N_2O$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

R" is selected from H, SO_2CH_3, $(CH_2)_2N(CH_3)_2$, $(CH_2)_{11}CH_3$, $C(S)NHC_6H_{11}O_5$, $(CH_2)_nN((CH)_o(CH_3))_2$, and an alkyl group having from 1 to 12 carbon atoms;

G is selected from OH, CH_3, and $(CH_3)_3C(CH_3)_2$;

X is selected from I, F, Cl, or Br;

a is 0 or 1;

b is an integer from 2 to 12;

c is 0 or 1;

d is an integer from 0 to 3;

e is an integer from 0 to 2;

f is 1 or 2;

g is 0 or 1;

n is an integer from 1 to 12;

o is an integer from 1 to 11; and

p is 1 or 2.

20. A salt of claim 19, wherein M is selected from $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $AlOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $CH_3SiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_3{}^+I^-]_2$; $Si[OSi(CH_3)_2(CH_2)_4NH_2]_2$; $Si[OSi(CH_3)_2(CH_2)_4NHSO_2CH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_4NHSO_2CH_3$; $HOSiOSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_4NHCSNHC_6H_{11}O_5]_2$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3OCOCH_3$; $Si[OSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3]_2 2I^-$; $(CH_3)_3C(CH_3)_2SiOSiOSi(CH_3)_2(CH_2)_4NCOC_{27}H_{30}N_2O$; $HOSiOSi(CH_3)_2(CH_2)_3OH$; $Si[OSi(CH_3)_2(CH_2)_3N(CH_2CH_3)(CH_2)_2N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8O$; $AlOSi(CH_3)_2(CH_2)_3N^+(CH_3)_2(CH_2)_{11}CH_3I^-$; $HOSiOSi(CH_3)_2(CH_2)_8N(CH_3)_2$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8O]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8S$;

$HOSiOSi(CH_3)_2(CH_2)_3N(CH_2)_3(CH_3)_2$; $HOSiOSi(CH_3)_2(CH_2)_3NCS$; $HOSiOSi(CH_3)_2(CH_2)_3N[(CH_2)_3N(CH_3)_2]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3$; $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NCH_3]_2$; $HOSiOSi(CH_3)_2(CH_2)_3NC_4H_8N(CH_2)_3CH_3$; or $Si[OSi(CH_3)_2(CH_2)_3NC_4H_8NH]_2$.

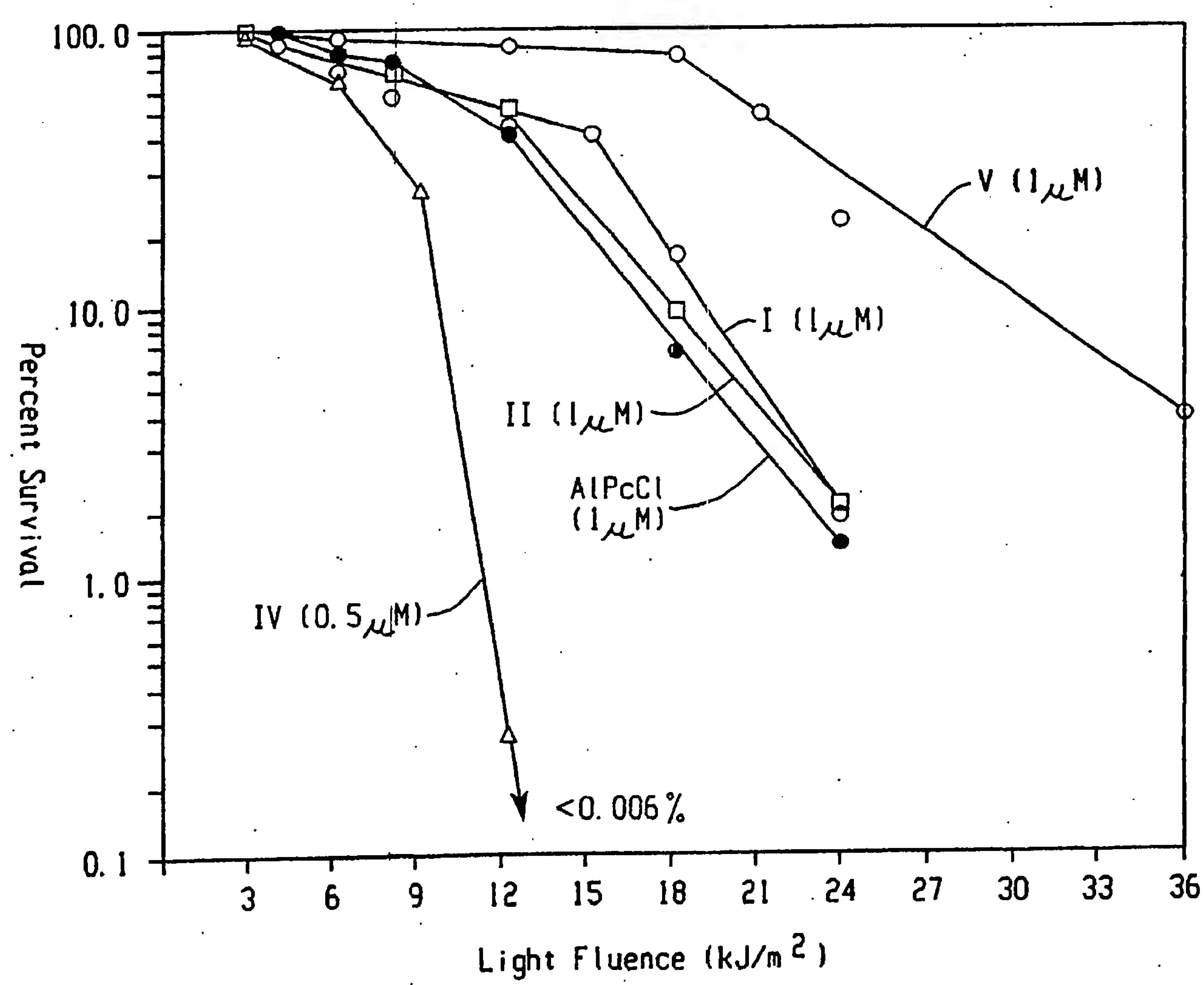
21. A salt of claim 20, wherein M is $HOSiOSi(CH_3)_2(CH_2)_3N(CH_3)_2$.

22. A salt of any one of claims 19 to 21, wherein the salt is the hydrochloric salt.

23. A salt of any one of claims 19 to 21, wherein the salt is the pyruvate salt.

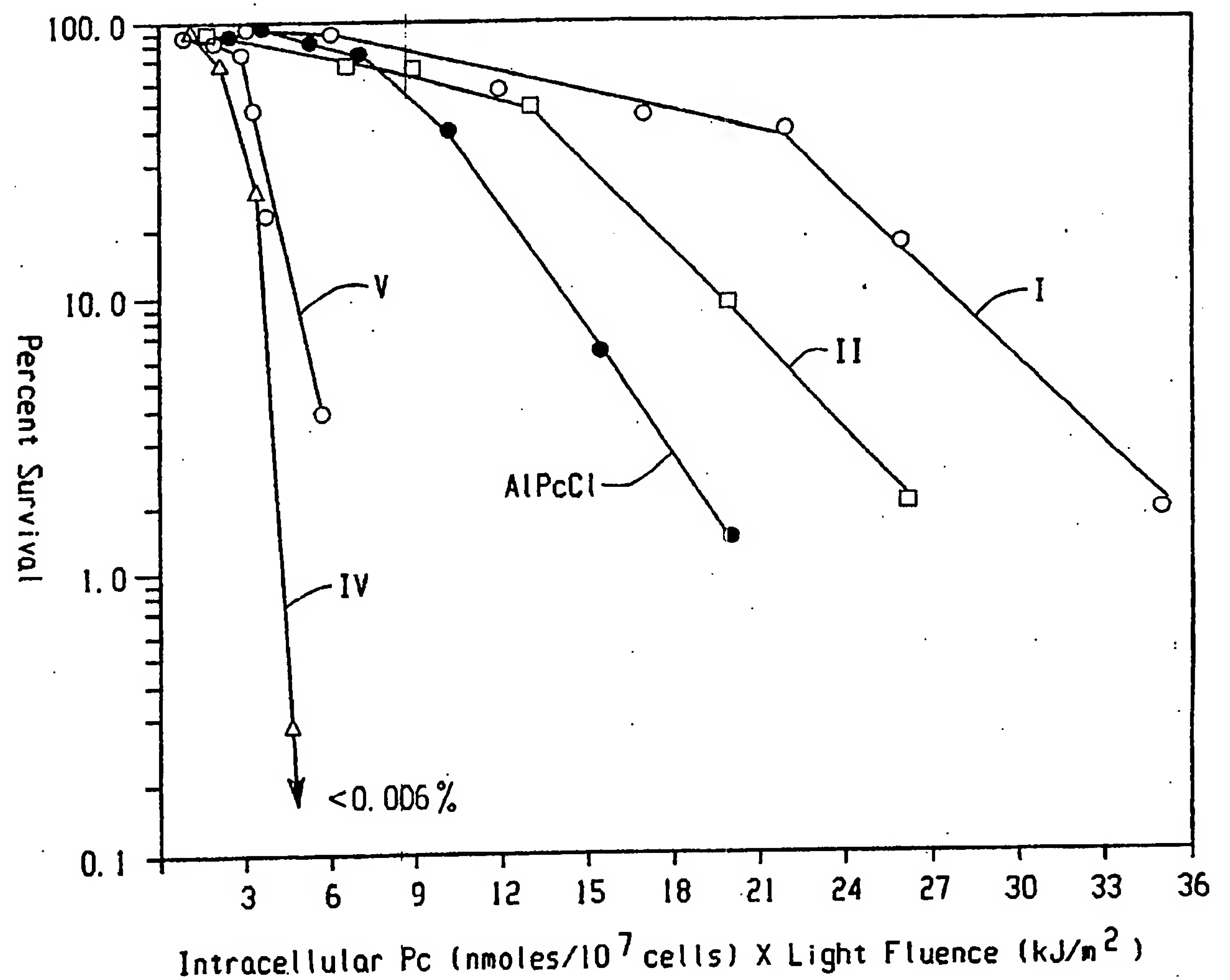
24. A pharmaceutical composition comprising a salt any one of claims 19 to 23 and a pharmaceutically acceptable carrier.

FIG. 1

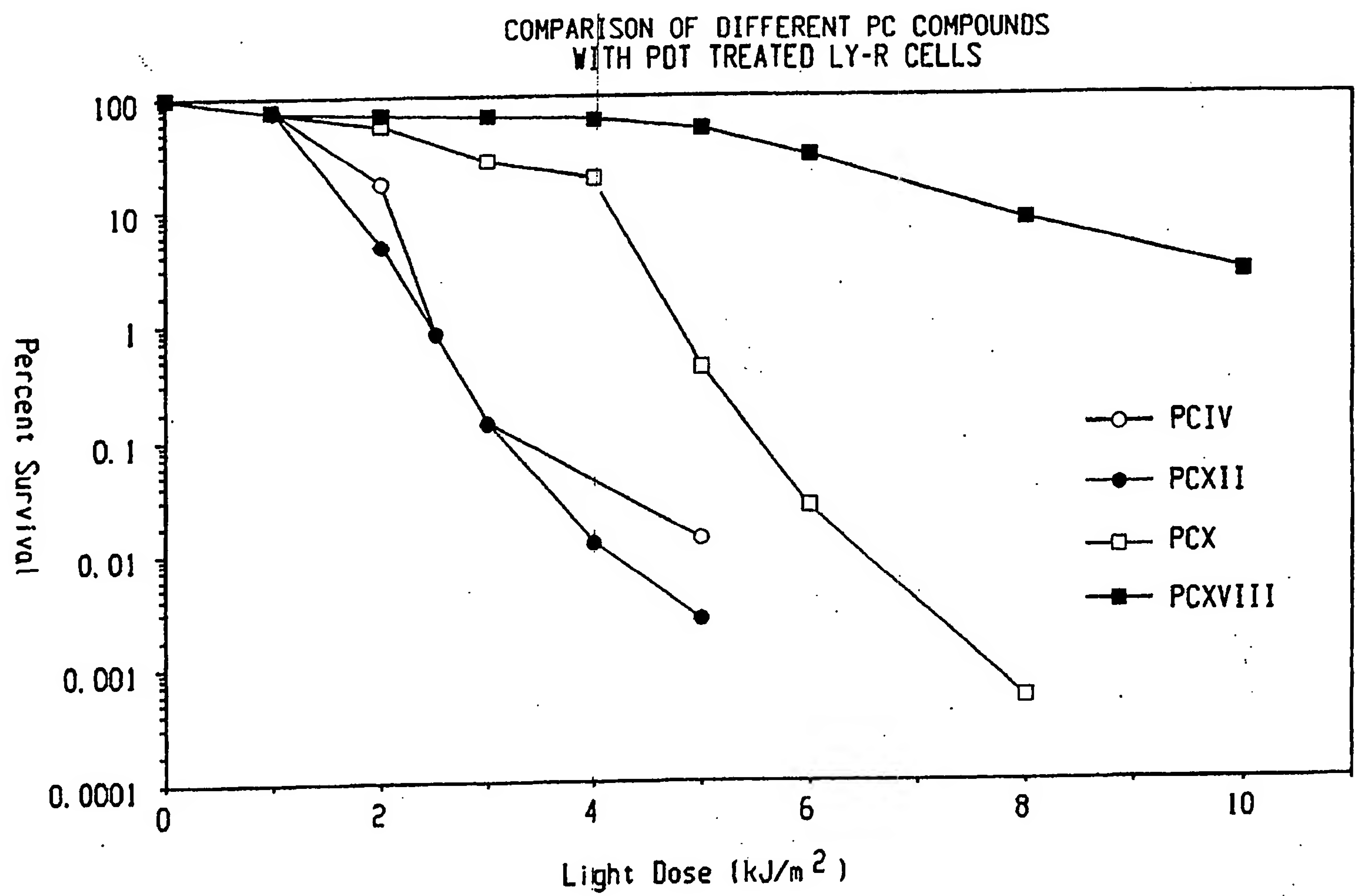


Percent Survival
100.0
10.0
1.0
0.1
3
6
9
12
15
18
21
24
27
30
33
36
Light Fluence (kJ/m 2)
V (1μM)
I (1μM)
II (1μM)
AlPcCl
(1μM)
IV (0.5μM)
<0.006%

FIG. 2



100.0
10.0
1.0
0.1
Percent Survival
3
6
9
12
15
18
21
24
27
30
33
36
Intracellular Pc (nmoles/10 7 cells) X Light Fluence (kJ/m 2)
I
II
AlPcCl
V
IV
<0.006%



COMPARISON OF DIFFERENT PC COMPOUNDS
WITH PDT TREATED LY-R CELLS
Percent Survival
100
10
1
0.1
0.01
0.001
0.0001
0
2
4
6
8
10
Light Dose (kJ/m2)
PCIV
PCXII
PCX
PCXVIII

FIG. 3

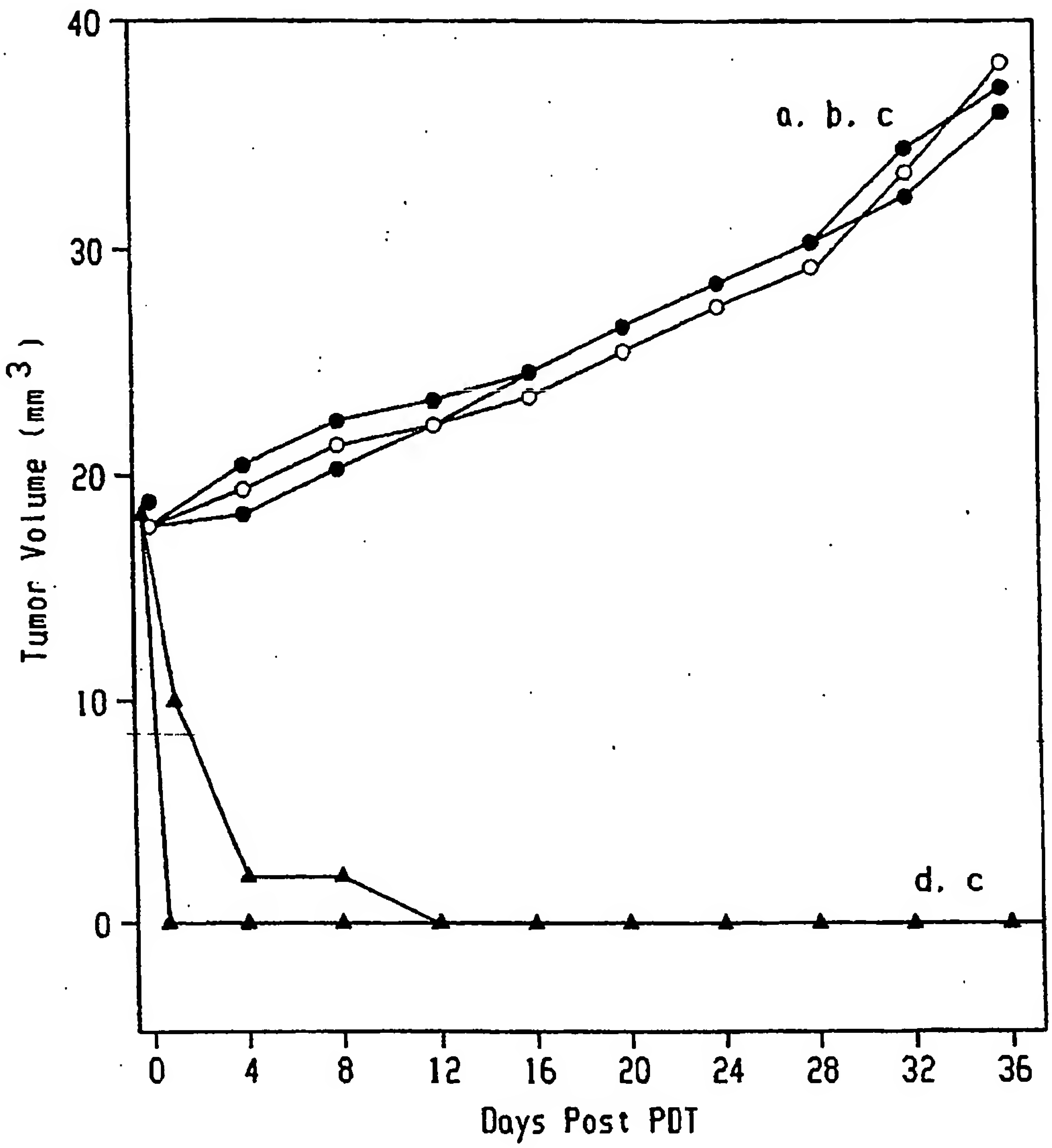
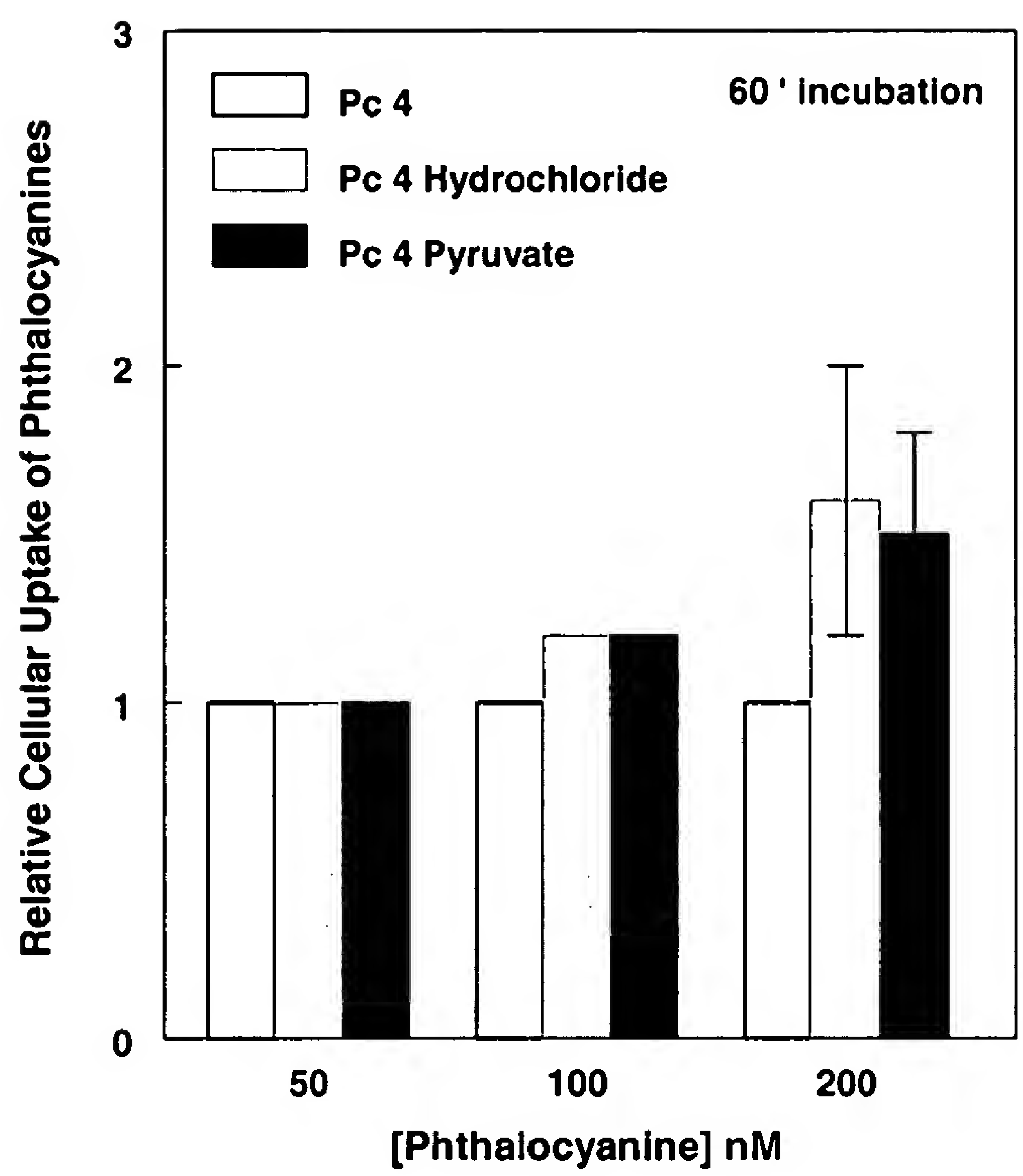

40
30
20
10
0
Tumor Volume (mm 3)
a. b. c
d. c
0
4
8
12
16
20
24
28
32
36
Days Post PDT

FIG. 4

FIGURE 5



3
2
1
0
Relative Cellular Uptake of Phthalocyanines
Pc 4
Pc 4 Hydrochloride
Pc 4 Pyruvate
60 ' incubation
50
100
200
[Phthalocyanine] nM

FIGURE 6

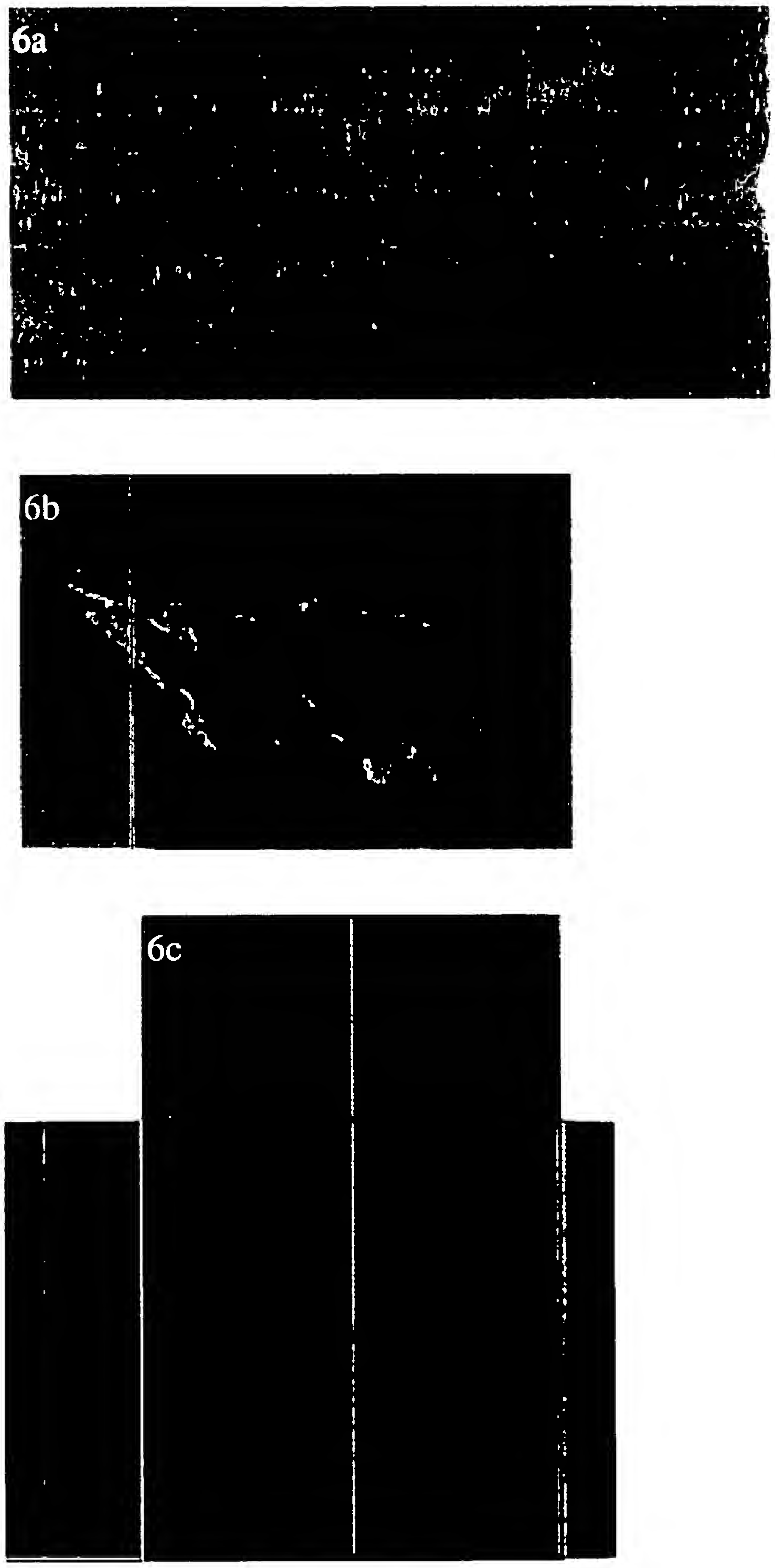
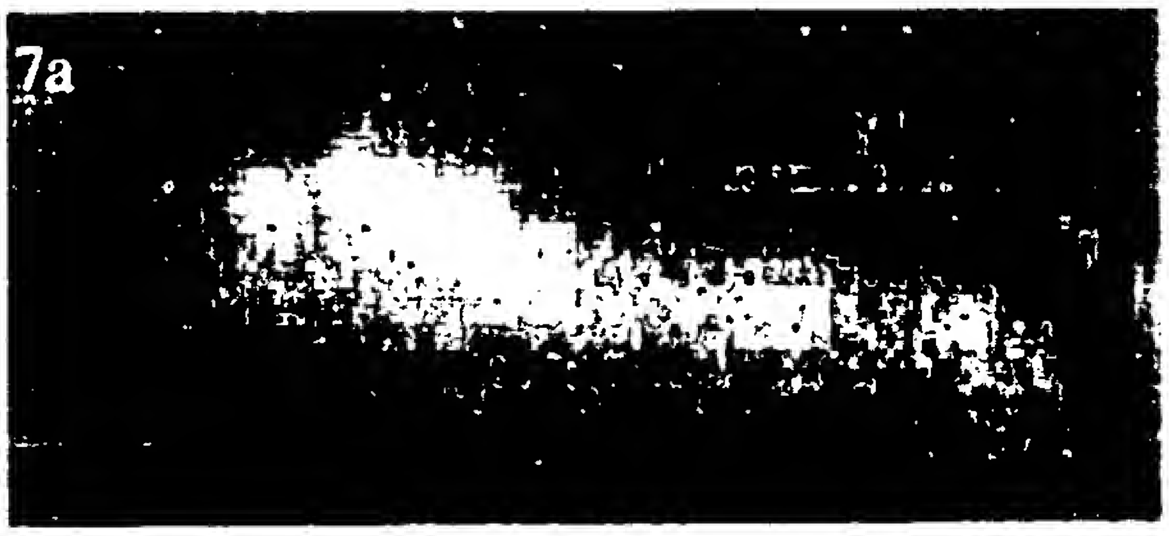


FIGURE 7



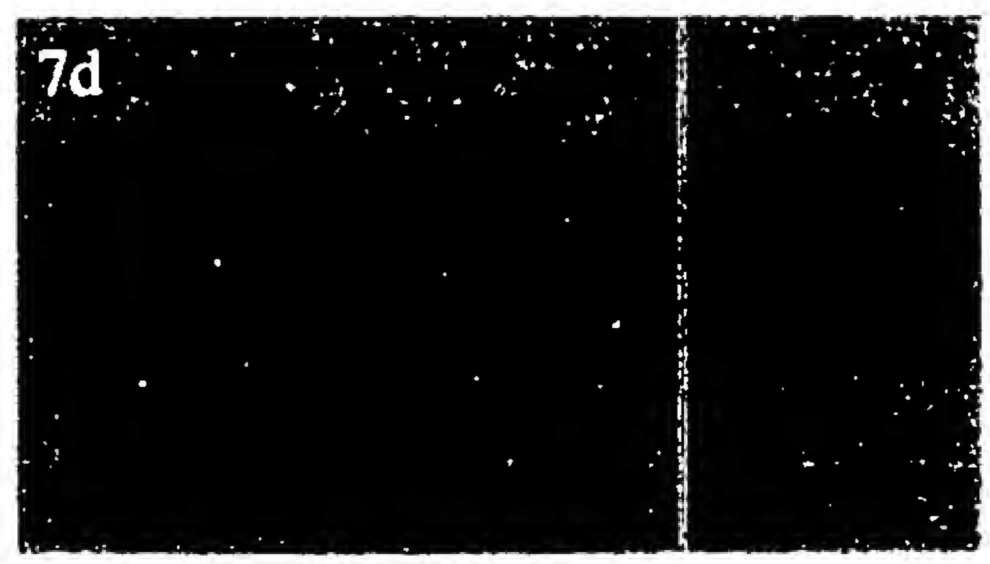


FIGURE 8